The PROGRESSIVE FISH-CULTURIST

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UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF FISHERIES
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PROGRESSIVE FISH-CULTURIST

ISSUED BY

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The PROGRESSIVE FISH-CULTURIST
News and Views from many Sources on Practical Hatchery Problems

Memorandum I-131 Washington, D. C. May - June 1940 No. 50

LAYING THE FOUNDATIONS OF FISHERY MANAGEMENT

A REVIEW OF THE AQUICULTURAL INVESTIGATIONS OF THE BUREAU OF FISHERIES

By H. S. Davis
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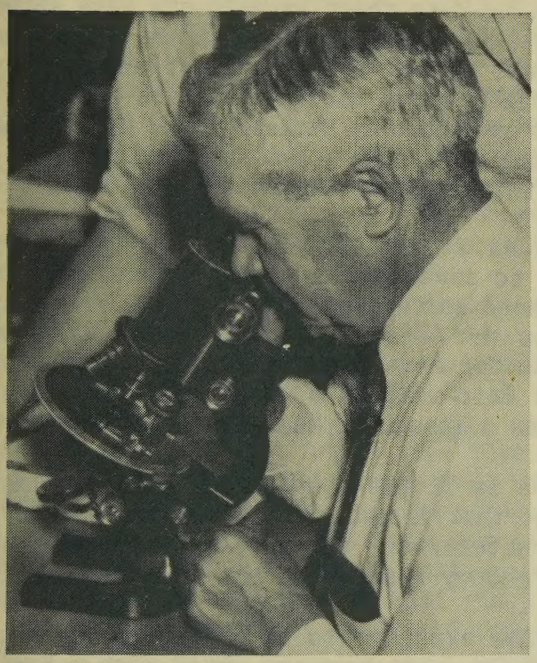

Dr. H. S. Davis

PROPER AND EFFICIENT utilization of the fish resources of our inland waters, it is now generally conceded, can be achieved only through the adoption of a comprehensive program of fishery management adapted to the needs of each body of water. The term "fishery management" is here used in its broadest sense to include artificial propagation and stocking as well as the scientific use of natural waters. The need for the development of management plans has served to focus attention on the lack of factual information on which such plans must be based. In an attempt to supply this much-needed information the work of the aquicultural investigations carried on by the Bureau of Fisheries has developed along three principal lines. One deals primarily with field problems designed to obtain information on the best means of insuring the maximum production of game and food fish consistent with environmental conditions. A second line of investigation is concerned with problems relating to the artificial propagation and rearing of fish, while a third deals with fish parasites and diseases with special attention to methods of control.

EASTERN TROUT STUDIES

The Bureau's investigations on trout in the eastern states have been concerned chiefly with the development of cheaper and better diets, with selective breeding and with the solution of field problems relating to fish management.

Feeding experiments.- The experiments with trout diets have dealt chiefly with the use of animal meals. Previous to the inauguration of these experiments the dry products ordinarily used in trout rations were the so-called cereals such as

cheap grades of flour,middlings, and oatmeal. Our experiments show that the chief value of these products lies in the fact that they provide roughage and absorb meat juices so that there is less waste in feeding. However, only a small part of these products can be digested by trout. In contrast to the cereals,animal meals such as fish meal, meat meal, salmon egg meal, and dried milk are easily digested and their inclusion in the diet has made it possible to grow better fish at less expense than with the diets formerly in use. In fact,these meals have proved so valuable that they are now in almost universal use.

Recent feeding experiments have been devoted chiefly to refinements of diets containing animal meals. For example, our experiments show that it is not advisable to use more than 50 percent of dry meals in the diet, under ordinary conditions. While trout can subsist on a diet containing considerably larger percentages of meals, the meals are utilized less efficiently and there is considerably more waste. Other studies show that growth is materially increased by the inclusion of a small amount of cod liver oil in the diet and that the addition of 3 percent of kelp meal has a similar effect. Furthermore, trout on diets containing both cod liver oil and kelp meal grow faster than when only one of these products is present.

Recently, experiments to determine the effect of the food on the number and quality of trout eggs have been undertaken. To date these experiments have shown that overfeeding,or an unbalanced diet, has a detrimental effect on the eggs, and a larger percentage fail to hatch. To produce eggs with the greatest hatchability at lowest cost the fish should be given a well-balanced diet in moderate amounts.[1]

Experiments carried out during the past two years at Hackettstown, N. J., and Leetown, W. Va., show conclusively that frozen fish when fed continuously in considerable quantities eventually produce definitely toxic effects.[2] The trout become dark in color and eventually die.

Feeding experiments are being continued at the Leetown (W. Va.) hatchery along much the same lines. It is planned to conduct additional experiments on the effect of various diets - especially those containing cod liver oil and kelp meal - on the eggs. Further experiments on the effect of these two products on growth are desirable. While the results so far have been remarkably consistent it is now planned to use cod liver oil and kelp meal in a wider range of diets. So far their use has been limited to rations composed of meat and different percentages of whitefish meal.

Since our experiments have shown there is little foundation for the belief commonly held by fish-culturists that a diet that is satisfactory at one hatchery may not prove equally successful at other hatcheries, our purpose is to develop a few standard diets that will give satisfactory results at the lowest possible cost.

Experiments in Selective Breeding.- The experiments in selective breeding were begun with brook trout at the Pittsford (Vt.) hatchery and until very recently the work has been confined to this station. These experiments resulted in more than doubling the rate of growth and the production of eggs in two generations. After that, as might be expected, the increase is much slower and requires rigid selection. The time at which trout spawn was also found to be a heritable character, so that by careful selection strains can be developed that will spawn at different times. Furthermore, all fish in any one strain will spawn within a

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[1]For an account of these experiments by Dr. James S. Gutsell, see pages 19 to 28 of this issue of the PROGRESSIVE FISH-CULTURIST.

[2]Gutsell, James S.
1940. Frozen fish in hatchery diets may be dangerous. The PROGRESSIVE FISH-CULTURIST,No. 48, pp. 28-32. (January-February)

very short time, which is in striking contrast with the brood stock at most hatcheries which spawn over a period of two or three months. Our experiments have also shown that it is possible to develop strains of trout that are more resistant to the ordinary hatchery diseases than are wild trout. This is especially noticeable in the case of furunculosis.

Breeding experiments with rainbow trout have been undertaken at the Leetown Station but have not been carried on long enough to give scientific results. There is no reason to believe, however,that the results will not prove as striking as those with brook trout. In addition to increasing the egg production and rate of growth an effort is being made to develop a strain of rainbow trout that will produce a large number of eggs in two years instead of the usual three.

Owing to lack of adequate facilities at Pittsford for continuing breeding experiments on a sufficiently large scale,it has been thought best to discontinue experimental work at this station. It is hoped, however, that in the near future more extensive breeding experiments can be undertaken at some other hatchery.

Fish Management Studies.- Fish management studies on trout waters are now being carried on at the Pittsford and Leetown stations and in the Pisgah Game Preserve in North Carolina. The work at the Pittsford station has been confined to the so-called "test waters" which have been operated in cooperation with the Vermont Fish and Game Service. This work was begun in 1935 on Furnace Brook by R. F. Lord. During the next year two more streams and Chittenden Reservoir were included in the program, thus increasing the number of test waters to four, the maximum number allowed by law. While the conditions under which the experiments have been carried on have not been all that could be desired, the results, nevertheless, are of great value and have gained nation-wide attention. They show that the fishing load is remarkably constant from year to year and that the great majority of fish are caught early in the season. The fishing in all three streams held up remarkably well and it is notable that the average catch late in the season was practically the same as earlier.

One of the surprising results was the clear indication that in all three streams the fishing is maintained chiefly by natural reproduction of wild fish and that stocking with hatchery trout has had little effect. In two streams it was found that natural reproduction alone is sufficient to maintain the fishing under present conditions and this may also be true of Furnace Brook. In this stream stocking with legal-size fish in the fall was found to be very wasteful. Of 5,000 trout planted in the fall of 1936 less than 12 percent were taken the following year, and of the same number planted in the fall of 1937 only 2 percent were taken by anglers the following season. In the face of these results stocking with large fish has been discontinued and we are now endeavoring to find whether stocking with smaller fish will yield any better results.

Another important result of the test stream studies is the fact that in Furnace Brook, which contains both brook and rainbow trout, the rainbow trout are maintaining themselves better than the brook trout. No rainbows have been planted in this stream for years but it has been stocked heavily with brook trout each year. In spite of this handicap the rainbow trout, which made up only one-third of the catch in 1935, have steadily increased and now compose about 60 per cent of the catch. In Chittenden Reservoir artificial stocking has been more successful, which agrees with information gained in other localities in indicating that stocking in lakes often gives better results than stocking in streams.

The test water studies have now reached a stage where complete control of the anglers will be necessary to get the required information. This control will be provided by the Vermont Fish and Game Service and will make it possible to determine definitely the effectiveness of artificial stocking.

During the last two or three years field studies on trout streams at the Leetown station have been confined to the St. Mary River in the George Washington National Forest. This stream is in a game management area and is consequently under the control of the U. S. Forest Service. Heavy plants of marked rainbow and brook trout have been made in this stream from time to time but the results reveal a staggering waste as shown in a recent paper by E. W. Surber.[3] Of 11,107 trout planted in this stream since 1935 only 268 or 2.4 percent have been recovered. The results reveal further that the planted fish grew very slowly and that considerable numbers of rainbow trout migrated downstream. There was also a marked decrease in the numbers of planted trout, even in the case of the brook trout which appear to stay in the section where planted. On the other hand, there is considerable natural reproduction of both brook and rainbow trout, which is the principal factor in maintaining the trout population.

Studies on this stream will be continued during the coming year. It has already been stocked with marked fingerlings, equal numbers of brook and rainbow trout being planted throughout the length of the stream. The procedure heretofore was to plant brook trout only in the headwaters and rainbow trout farther downstream. North Creek, a stream of different type, situated a short distance south of the St. Mary River, will also be placed on an experimental basis this year. This stream is believed to provide better conditions for trout than the St. Mary, and it will afford an excellent opportunity to determine whether rainbow trout show a greater tendency to remain where planted when the environment is more suitable.

The work in the Pisgah National Forest under T. K. Chamberlain is on a somewhat different basis than in other regions. In the Pisgah Game Preserve the U. S. Forest Service has complete control over all wildlife and consequently the waters of this area afford an exceptional opportunity for experiments in fish management, and for a demonstration of what can be accomplished by scientific methods. The rearing station on the Davidson River supplies all trout of various sizes needed for stocking. All stocking is done according to plans worked out by the Bureau of Fisheries and a complete record is kept of all trout taken by anglers.

As a background for the experimental work, very complete food studies have been made and all streams have been mapped on a scale of one inch to 100 feet. Stocking has been carried out systematically, according to plans based on the stream surveys. An encouraging degree of improvement in fishing has resulted. In fact, it is becoming apparent that some of the streams are now overstocked and as a result the need for lighter rather than heavier stocking is being emphasized.

As was the case in Vermont, however, stocking with large fish in the fall has not been successful. The fish lose weight during the winter and when the fishing season opens they are in poor condition. Many of them disappear and only a small percentage are caught by anglers.

Our studies have shown that brook trout tend to remain where planted even though there is very little food to be had and there are no obstacles to their descent to more favorable sections. These facts have an important bearing on the use of so-called nursery streams. In many states the headwaters of trout streams are closed permanently to fishing in the belief that such streams will act as nurseries for young trout which, as they grow larger, will drop downstream to open waters where they can be taken by anglers. It is now evident that with brook trout, at least, the results are quite different and permanent closure of small streams will simply result in their becoming overcrowded.

If we are to manage a stream successfully we must know something about the numbers and condition of the fish unless we are to work more or less in the dark. Heretofore the creel census has been the chief means of determining the success

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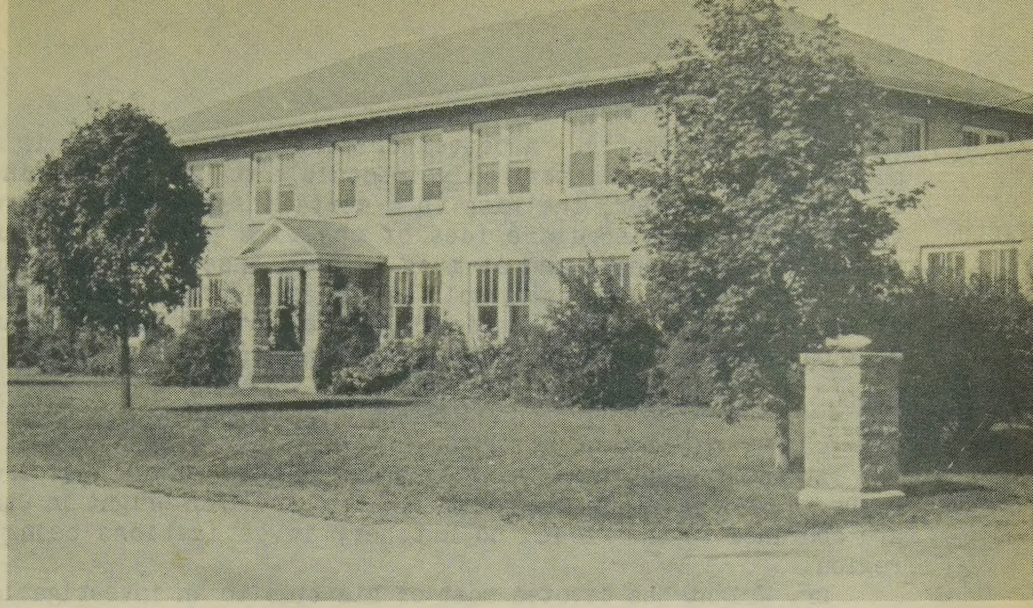
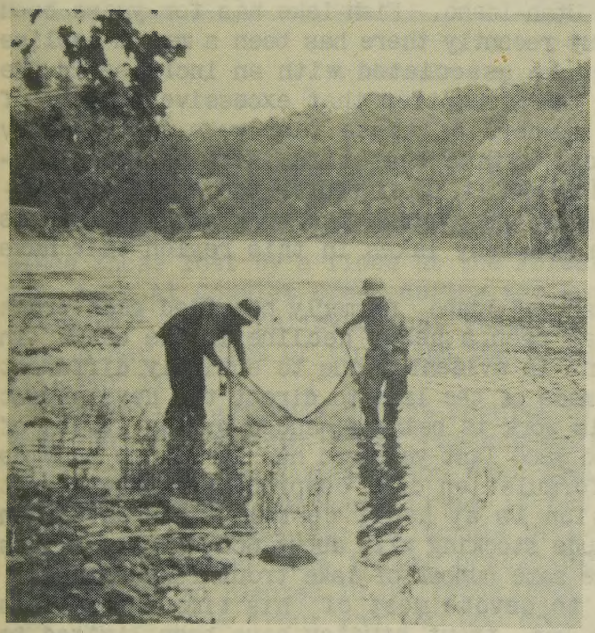
[3]Surber, Eugene W.
1940. An appraisal of the results of planting fingerling trout in St. Mary River, Virginia. The PROGRESSIVE FISH CULTURIST, No. 49, pp. 1-13. (March-April).

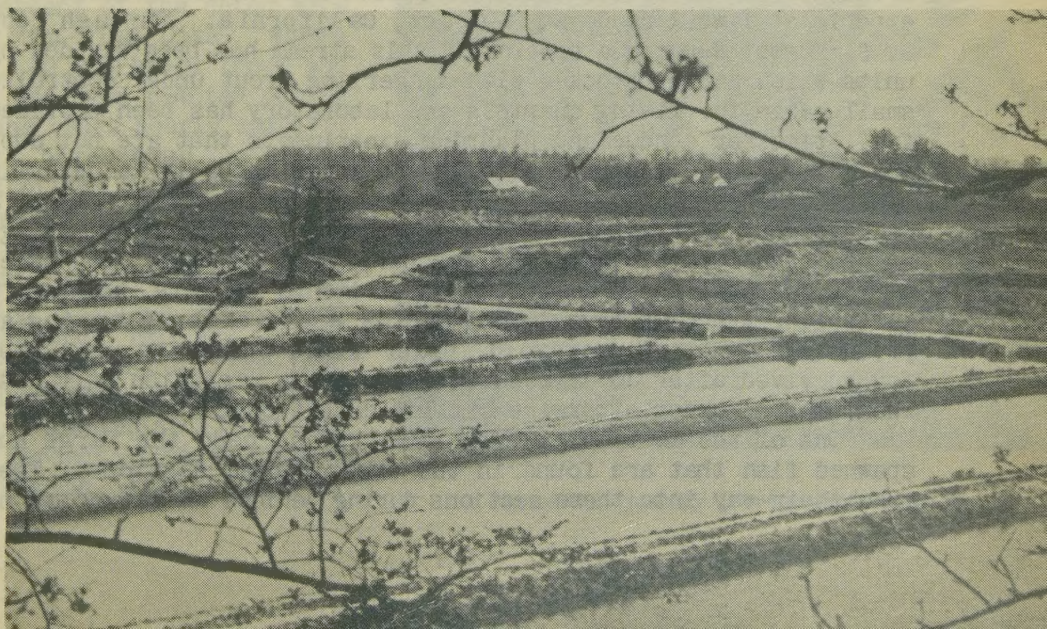




(Above) Main building, Leetown (W. Va.) Station

(Left) Collecting bass fry in the Shenandoah River

(Below) Experimental bass ponds at Leetown



or failure of stocking. A better criterion would be a fair sample of the fish population but it is practically impossible to use a seine in the average trout stream. If, however, the fish in a certain section of a stream can be stunned temporarily a more accurate idea of the fish population can be obtained than through a creel census and at much less expense. Two methods of stunning fish are by chemicals, such as cresol, as suggested by Dr. Embody, and by electricity. It is planned to devote considerable time during the next year to an attempt to work out a satisfactory method of sampling streams.

WESTERN TROUT STUDIES

At the present time the only trout studies in the West are being carried on by Dr. P. R.Needham in California and Dr. Stillman Wright in Utah. These studies are confined to the field, no hatchery investigations being under way in this region.

Dr. Wright has devoted most of his time to an investigation of fishery problems in Fish Lake, Utah, and Bear Lake, Utah-Idaho. Fish Lake has for years been famous for its excellent trout fishing but recently there has been a marked decline in the catch. This decline appeared to be associated with an increase in the abundance of the Utah chub. Acting on the assumption that excessive numbers of chub were detrimental to trout, large numbers of these fish were destroyed by derris root under Dr. Wright's direction. Since that time there has been considerable improvement in the trout fishing but it is,of course,too early to conclude that this was due to the decrease in the chub. The work on Fish Lake is of more than local interest since there are many lakes in this region that have similar conditions.

Bear Lake, which lies equally in Utah and Idaho, formerly provided good trout fishing, but, as in Fish Lake, there has been a heavy decline in the catch in recent years. Here, however, the decline is evidently due to entirely different causes and a biological survey has been made of the lake to direct the development of plans for improving the fishing. This work is being financed by the States of Idaho and Utah, each of which contributed $800 last year and has agreed to provide $920 for the work in 1940. While the formulation of a comprehensive management plan is impossible until more information is at hand, certain steps have been taken to improve the fishing. These include stocking with about 600,000 fingerlings of the native trout and approximately the same number of lake trout fingerlings.

Since Dr.Needham has been obliged to devote most of his time to problems arising from the construction of Shasta Dam, trout studies have been limited to experimental work on Convict Creek, California. Through cooperation with the U. S. Forest Service a section of this stream has been divided by dams into small units which can be stocked with fingerling trout under controlled conditions. A small cabin for living quarters and laboratory has been provided and we now have facilities for conducting planting experiments that are not duplicated elsewhere in the country. The purpose of these experiments is to determine the extent and causes of losses among young trout under various conditions, a matter on which we have very little information at present. Unfortunately, owing to lack of funds it has been impossible to analyze carefully the data that have been accumulated during the past two seasons. The experiments indicate, however, that losses among fingerling trout during the first few weeks after planting are due chiefly to predacious fish. For example, under light predation, 21.7 percent of cutthroat fry survived after 50 days while under heavy predation only 1.4 percent survived when planted under otherwise similar conditions.

One of the most surprising results has been the large number of naturally spawned fish that are found in the experimental sections. These fish evidently make their way into these sections during periods when they are not being operated.

A fish-planting crew in the Pisgah National Forest.
(Forest Service Photo)

It is planned to continue operations during the summer of 1940, stocking at different intensities and using various sizes of brook, brown and rainbow trout.

A number of Mexican trout were collected in Baja California, Mexico, to replace those lost by a flood at the Forest Home Hatchery, California. These fish were held at Convict Creek during the summer and are now at the Clackamas (Ore.) hatchery. It is believed that these fish are more tolerant of high temperatures than other species of trout and therefore may succeed in waters where other trout will not live.

Striking evidence on the results of stream stocking in various regions has been obtained through catch records taken on Squaw Creek, California, and Fish Lake, Oregon, in cooperation with the Forest Service. On Squaw Creek it was found that, although the California Division of Fish and Game in the preceding five years had planted 10,000 brook trout, 120,000 rainbow trout and 140,000 brown trout, over 99 percent of the catch were rainbow trout. In Fish Lake, where 20,000 cutthroat, 40,000 brook trout and no rainbow trout had been planted during the three preceding years nearly complete records show that here, also, approximately 99 percent of the catch were rainbow trout. However, in Angora Lake, California, much better results were obtained from artificial stocking. In the fall of 1933, 5,000 two-inch brook trout were planted in the lake. This was followed by an additional plant of five-inch brook trout in June 1935. During 1935 3 percent of the fish planted as fingerlings in 1933 and 22.7 percent of those planted earlier in the season were caught by anglers.

End of the journey (Forest Service Photo)

This spring work is being initiated at the Clackamas (Ore.) station, where in addition to the laboratory, one of the hatchery buildings and a number of outdoor pools are available for experiments. Fish-cultural studies at this station will include feeding experiments with both trout and salmon. The latter are considered especially important since the present great increase in salmon propagation has created a need for an inexpensive diet that will give better results than those now in use. Silver salmon, for instance, on the present diets suffer a very heavy mortality when they reach a length of 1½ to 2 inches. The evidence at hand indicates that a satisfactory diet for salmon may be entirely different from those found most desirable for trout. Other problems of salmon culture that will be studied at Clackamas include a study of the parasites and diseases that are now exacting a heavy toll of fingerlings.

In addition to investigations relating to fish-cultural operations, systematic field studies of trout are to be undertaken. Plans for these studies cannot be worked out in detail until we have more information regarding the possibilities and the problems which most urgently need attention. It is proposed, however, to devote special attention to the competition between trout and young salmon - a problem that has received practically no attention although it is unquestionably of supreme importance. With the increased demands on salmon streams below dams it may be necessary to limit the number of trout in these streams. Possibly the final solution may be to set aside certain streams for trout, others for salmon. In streams that are obstructed by dams it may be better to reserve the stream for trout above the dam and for salmon below the dam. The Clackamas River affords an exceptional opportunity for a study of this problem. There is now considerable agitation to compel the power company to construct a fish ladder to allow salmon to ascend to the headwaters, although for years there have been no salmon in the stream above the dam, where now there is excellent trout fishing.

STUDIES ON BASS AND OTHER WARM-WATER FISHES

Investigations dealing with warm-water fishes are being conducted at the Leetown (W.Va.) and Welaka (Fla.) stations. Owing to lack of sufficient funds for experimental work the investigations at Leetown under E. W. Surber have been limited almost entirely to field studies. For this purpose experimental sections each several miles in length have been utilized on four streams: the North Fork of the Shenandoah River and the main river above Berryville in Virginia, and the South Branch of the Potomac and the Cacapon River in West Virginia. Although all four streams are famous for their bass fishing, the general characteristics of the Shenandoah and its tributary are quite different from those of the West Virginia streams. In the systematic studies carried on in these streams for several years, emphasis has been placed on food conditions, relation of bass to other fish in the streams and the extent of natural reproduction. While insects and similar organisms are abundant in all four streams, forage fish are notably lacking in the South Branch and in the Cacapon River. This condition is believed to be responsible for the fact that, on the average, it requires four years for bass to reach legal size in the West Virginia streams but only three years in the Shenandoah. Under present conditions both of the West Virginia streams are overstocked with bass. As a result, young bass spawn before reaching legal size and the streams are filled with small fish which in numbers are all out of proportion to those of legal size. The obvious remedy is to reduce the size limit or stock heavily with forage fish. Probably both methods should be employed.

Studies on the spawning of bass in these streams have shown that large numbers of young are hatched each year. For example, a careful count of the bass nests in the South Branch of the Potomac River indicated an average hatch of 115,000 fry

Experimental bass ponds at the Welaka (Fla.) Station.

Treating a lake in the Ocala National Forest with derris root.

per mile of stream. There are approximately 75 miles of bass water in this stream and if we assume an average of 100,000 fry per mile we find that it would require 7,500,000 fry to stock the stream at the same rate as is done by nature.

It has been found, however, that the number of young bass decreases rapidly a short time after they leave the nest and the loss appears to be greater than in hatchery ponds under ordinary conditions. Mr. Surber's studies show that a large part of the loss is due to predacious fish, especially young bass in their second and third year. Parasites, of which bass have their full share, may be an additional cause of loss.

In the future the nature of the field studies will be changed materially and more attention will be paid to angling conditions. Arrangements have been made with the West Virginia Conservation Commission to require all anglers fishing the experimental sections to make a complete report of their catch. Young bass with belly tags will be planted in these sections to determine to what extent hatchery-reared fish enter into the angler's catch. The evidence at hand indicates that natural propagation is more efficient than in the case of trout and that with proper regulation little stocking will be required. At present we know of absolutely no evidence to indicate that in waters already containing bass in any numbers artificial stocking has improved angling conditions.

Twenty-four new ponds designed especially for experimental work have now been completed at the Leetown station, and will be utilized in an extensive series of experiments during the coming season. Among the subjects to be investigated are the use of fertilizers and forage fish and the control of aquatic plants.

Plans have also been completed for rearing forage fish for stocking bass waters. It appears that in many waters this would improve the fishing more than to stock with bass.

Both pond experiments and field studies are being carried on at the Welaka (Fla.) station by O. L. Meehean. However, only a few ponds were available for experimental work last season. These were stocked with bass fry and fertilized according to a procedure developed by Mr. Meehean in previous experiments at Natchitoches, Louisiana, and Marion, Alabama.[4] These ponds produced an average of over 12,000 2½ inch bass per acre which is more than twice as many fish as were produced in similar ponds operated according to usual fish-cultural methods. One pond was stocked a second time with bass fry so that two crops of fingerlings were produced in one season, with a total production of 19,887 fish per acre. Results of experiments with bream as forage fish for bass according to the methods employed at many of the Bureau's hatcheries in the South were disappointing.

It is evident that under conditions in Florida new methods of handling bass can be developed that will greatly increase production. During 1940 additional ponds will be available for experimental work. Special attention will be paid to experiments designed to afford a comparison between organic and inorganic fertilizers. The ponds at Welaka are admirably adapted to such experiments since the sand bottoms will supply very little nutrient material.

In addition to experiments at the hatchery, Mr. Meehean has devoted considerable time to work in the Ocala National Forest, which, with its many lakes, affords unique facilities for a study of management problems. Through a cooperative agreement with the U. S. Forest Service and the Florida Commission of Game and Freshwater Fish eventual control of all lakes in this area is contemplated. These experiments in management will unquestionably yield results of great value in the management of waters throughout the South.

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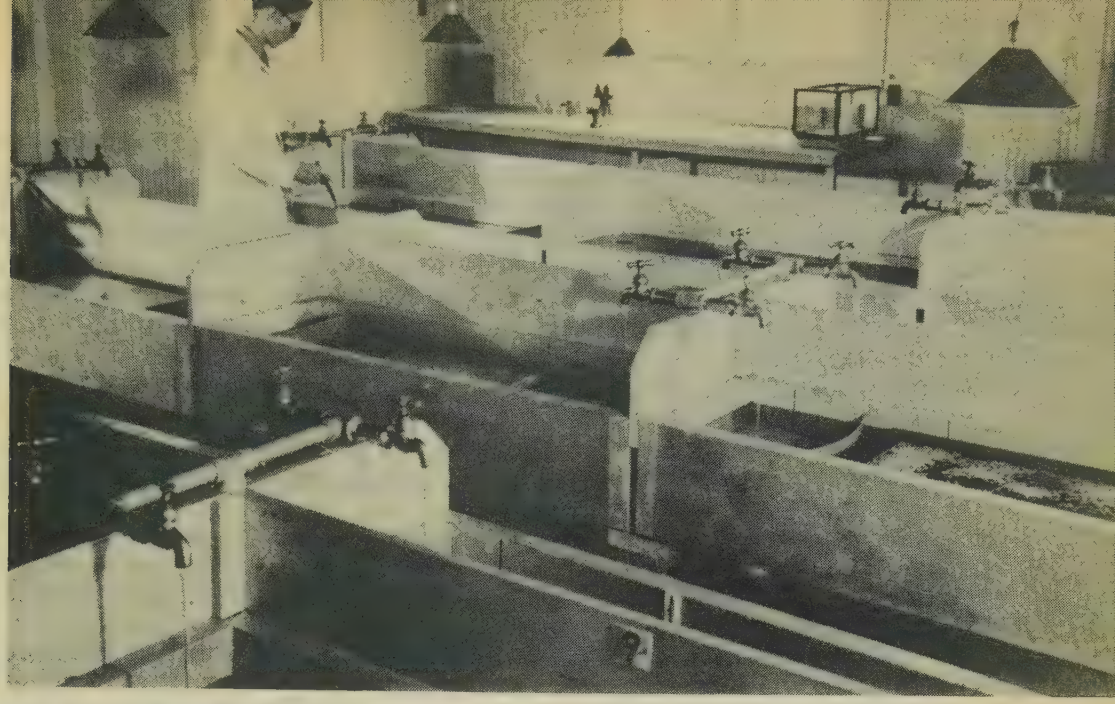
[4] Meehean, O. L.
1939. A method for the production of largemouth bass on natural food in fertilized ponds. The PROGRESSIVE FISH-CULTURIST, No. 47, pp. 1-19. (November-December)



Fish pathology laboratory at Quilcene.

Dr. Fish preparing diseased tissue for microscopic examination.

INVESTIGATIONS ON PARASITES AND DISEASES

Studies on parasites and diseases of fish are being conducted by Dr. F. F. Fish at the Seattle Laboratory and by the writer at the Leetown station. Facilities at Seattle for the study of problems relating to fish diseases recently have been greatly increased. Two experimental laboratories are now available: One at the Quilcene (Wash.) hatchery and the other in the basement of the fisheries laboratory at the University of Washington.

Most of Dr. Fish's activities have been devoted to infection experiments with ectoparasitic protozoa and to developing a method of treating fish for external parasites without removing them from the pond. Extensive tests have been

made with several chemicals. A very dilute solution of formalin appears to be most effective since it kills all external protozoan parasites with very little injury to the host.[5] Dr. Fish is now engaged in perfecting the details of this treatment so that it can be used by fish-culturists without danger of serious injury to the fish. This treatment promises to be much superior to the dipping method now in general use, especially for fish in ponds or raceways.

Trout in many western hatcheries have for years suffered from a disease of the gills that is quite distinct from the gill disease common at eastern hatcheries, which is caused by infection with a specific bacterium. Dr. Fish's studies indicate that the western type of gill disease may be due to different causes and that the same treatment cannot be expected to be effective in all cases. Frequently it is caused by a protozoan parasite, Costia necatrix, which is easily controlled by the use of formalin.

In connection with his studies of diseases, Dr. Fish has carefully analyzed the records of losses at western hatcheries. These records of 288 different lots of fish at 22 hatcheries show an average loss of 50 percent between the eggs and no. 4 fingerling stage.

At Leetown special attention has been paid to the parasites of fry and fingerling bass. These parasites are apparently responsible in large part for the disappearance of great numbers of fry shortly after they leave the nest. Studies of a new protozoan parasite on the gills of smallmouth bass have been completed and the results will shortly be ready for publication. This parasite has at times caused serious losses among both fingerling and adult bass. The bacterial gill disease common among trout at many hatcheries has been found to affect bass also and has caused considerable mortality among fingerlings being held for distribution. Studies on fin rot and a new fungus disease of the alimentary tract of trout are also under way.

In addition to continuing these studies, it is planned to get more information on the common diseases of trout and bass whenever an opportunity arises. There is still much to be learned about even the best known diseases which would be most valuable in working out better methods of control.

The Bureau's pathologists devote considerable time throughout the year to the disease service which is available to state as well as federal hatcheries and has proved very popular.

FUTURE TRENDS OF FISH CULTURE

In conclusion I would like to emphasize the importance of continuing the field studies. Only in this way can we obtain the information essential for improvement of our stocking policies. In view of the large amounts expended annually by the Bureau and many states on artificial propagation of game fishes it is remarkable that, until very recently, no attempt was made to determine whether or not our present stocking methods are producing results. We are confronted with an anomalous situation in which a highly organized industry producing an extremely perishable product at great labor and expense has been almost entirely oblivious to the fate of that product once it leaves the hatchery. Both fish-culturists and anglers call for fish and still more fish without attempting to determine whether increased production is the answer to the almost universal complaint that fishing is growing poorer each year.

Our studies up to the present time indicate that with the same expenditure of money and effort, the efficiency of the entire system of game-fish production

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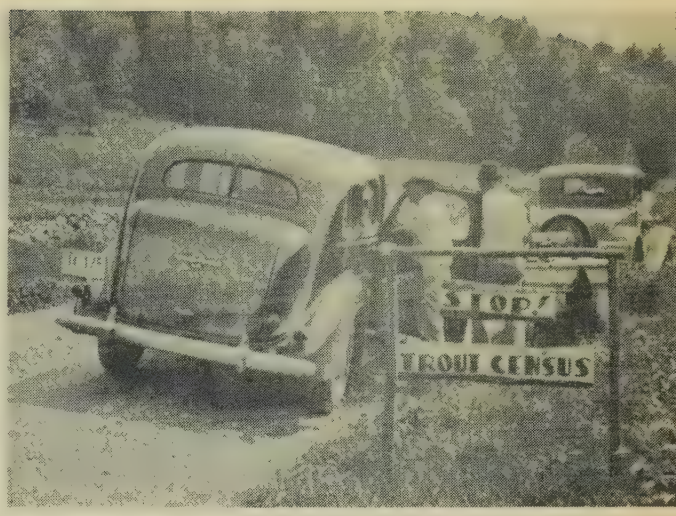
[5] Fish, F. F.
1940. Formalin for external protozoan parasites. The PROGRESSIVE FISH-CULTURIST, No. 48, pp. 1-10. (January-February)

could be doubled. Most fish-culturists will, no doubt, disagree with this statement but in view of the known facts the burden of proof is on those who hold that present stocking practices are efficient and justifiable.

Our studies are, of course, far from complete but aside from this fact there is no reason to believe they have given us a distorted picture of the situation. However, it is evident that more work is required before we can feel assured that this is not the case. Conditions in the field cannot be controlled as in a laboratory experiment or even one conducted in a hatchery pond and conclusions must be based on cumulative evidence obtained through systematic studies continued over a period of years in widely separated sections of the country.

Even though further studies should show that our tentative conclusions are fully justified it would not necessarily mean that artificial stocking, as such, is a failure. It may very well be that improvements can be made in present practices that will greatly increase stocking efficiency. The results of management in the Pisgah Game Preserve encourage the belief that stocking may be successful when properly adjusted to the water in question. There is evidence that stocking in lakes has been more successful than in streams. Furthermore, stocking with large fish just before and during the fishing season, as is now done in several states, has produced satisfactory results although, even here, there is doubtless room for improvement. There is also reason to believe that many of our stocking failures have been due to planting the wrong fish and consequently there has been lack of complete adjustment between the fish and their environment. Another frequent cause of failure is lack of sufficient care in planting.

It is apparent that the great need at present is to increase the effectiveness of our stocking methods rather than to build more hatcheries. There are great possibilities in this direction but we cannot hope to realize them without long and painstaking studies and experiments.



Anglers fishing Vermont test streams stop for the fishery census taker.

(Below) Marking fingerling trout before planting in the streams of the Pisgah Forest.

TURTLES

Friends or Foes of Fish Culture ?

By Karl F. Lagler
Department of Zoology
University of Michigan

DO TURTLES HINDER or help the fish-culturist? Are they a benefit to fishing or have they no relation at all to game-fish crops? What should be the fish-culturist's attitude toward the aquatic members of this group of reptiles?

Data have been assembled in Michigan which are useful in answering these and similar questions. The information in hand has been obtained largely from laboratory examination of the contents of the digestive tracts of more than nine hundred turtles, mostly from southern Michigan. Snapping, Blanding's, map, western painted, spiny soft-shelled (rubber-back), and musk turtles comprised a large majority of the specimens examined. Field investigations were conducted on hatchery and natural waters to determine where and how these turtles live, to find the relative abundance of the various kinds, and to learn how they are related to man in ways other than as fish predators.

Most of the specimens studied in the laboratory were collected in conventional, barrel-shaped turtle traps of the type shown in the accompanying illustrations. A detailed description of the method is given later in this paper.

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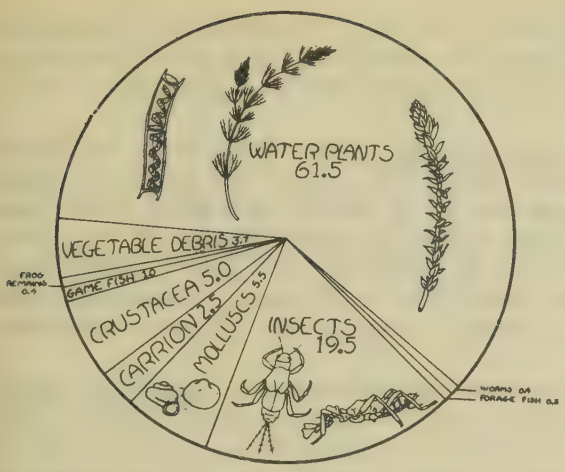
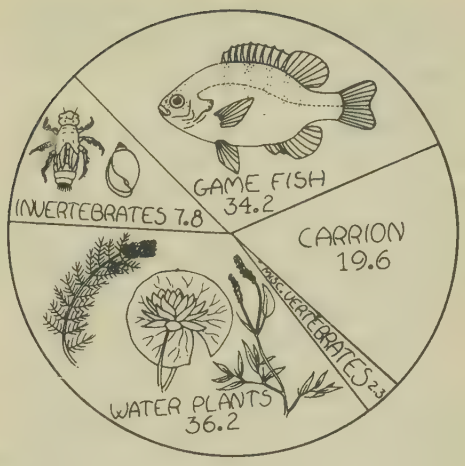
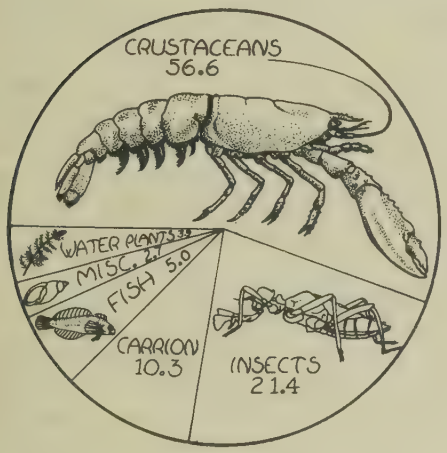
[1] Based on research made possible by the cooperation of the Institute for Fisheries Research, of the Michigan Department of Conservation, the American Wildlife Institute, and the University of Michigan. A part of this report has also been published in AMERICAN WILDLIFE for January-February, 1940.



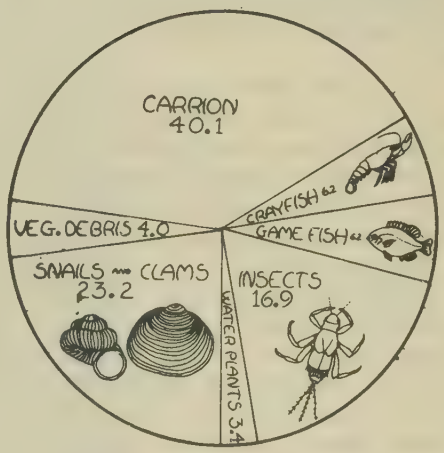
Western painted turtle



Snapping turtle



Blanding's turtle



Musk turtle

The food of several common turtles.
(Charts prepared by J. Roemhild)

The food of these turtles, especially that of the common snapper, differs markedly from that recorded by previous writers on the basis of less extensive studies. About four quarts of food from the stomachs of 186 snapping turtles (Chelydra serpentina) collected on natural waters was made up as follows: one-third, water plants; the second third, game fishes; and the last third, dead fishes and other carrion, insects, crayfishes, snails, and clams (see diagram). Remains of water-plants made up a little more than nine-tenths of the food (about nine quarts) in the intestines of 278 snappers. These findings are considerably at odds with the current general opinions that this turtle is entirely carnivorous, and that it subsists principally on fish and young waterfowl. Twenty-one snappers taken from bluegill and bass rearing ponds had not eaten significantly more game fish, on the average, than had those from wild waters. The major occasions for

concern over this turtle at hatcheries appear to be: (1) when the fishes are extremely crowded in raceways, (2) where eggs of pondfishes are placed on trays in rearing ponds, and (3) when the fishes are concentrated in a seining or holding pool.

Blanding's or the semi-box turtle (Emys blandingii) was discovered to forage chiefly upon crayfishes and aquatic insect larvae in lakes and ponds. Small amounts of carrion, leeches, snails, clams and water weeds were also taken (see diagram). In fish-rearing waters the fishes being cultured appear in the food.

Map turtles (Graptemys geographica) from wild waters had eaten crayfishes, snails, and clams. Also included in their food were a few small fishes and some carrion, insects, and now and then a little aquatic vegetation. No specimens were available for study from hatcheries.

About two-thirds of the food of the western painted turtles (Chrysemys picta marginata) in lakes and ponds was composed of water plants (see diagram). The remaining third was made up chiefly of insects, but includes also some fish remains, leeches, earthworms, crayfishes, scuds, snails, and clams. In hatcheries or rearing ponds, this turtle may prey on eggs and fry and for this reason probably should be removed or excluded from such waters.

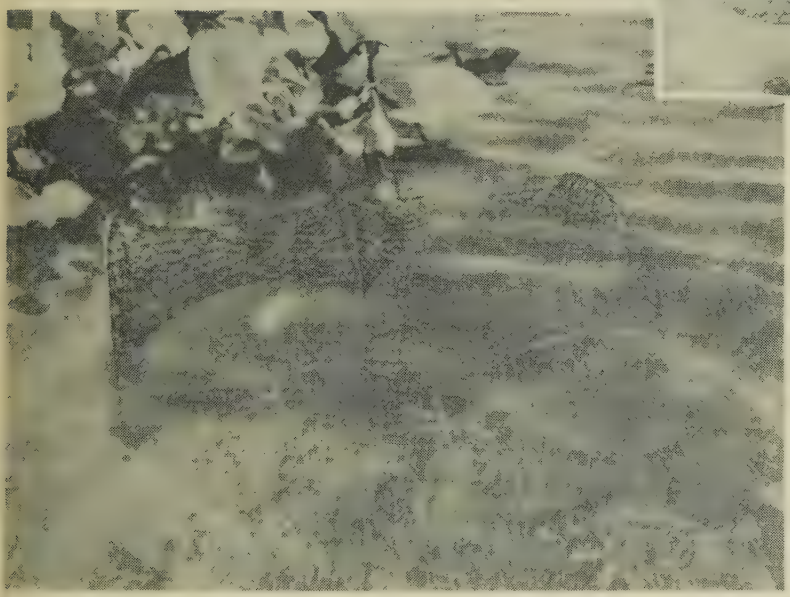
That very adept swimmer, the soft-shelled turtle (Amyda s. spinifera), long thought to prey extensively on fish, was found to feed mostly on crayfishes and burrowing mayfly larvae and other insects. None were studied from fish-cultural waters.

The musk turtle or stink-pot (Sternotherus odoratus) which is so often mistaken for a young snapping turtle, when taken from natural waters had eaten principally carrion, crayfishes, insects, snails, clams, and the hard-coated seeds of water plants (see diagram). At hatcheries there is some evidence that it feeds on eggs and fry, especially those of bass or sunfish. More than a thousand bluegill larvae were found in the stomach of a musk turtle taken from a bluegill nest in a rearing pond.

On the basis of the materials examined from wild waters it seems that ofthese six common aquatic turtles, the snapper alone eats appreciable amounts of fish. In order to give an idea of the significance of the snapper to game fish populations, the following estimates seem justified. It may be assumed that each of the 186 stomachs which contained food held the remains of less than one "meal" and that each of the 278 intestines which contained food held the remains of more than one meal. Together these may be taken to total 454 meals. The 275 game fishes eaten by these turtles then average about six-tenths of an individual per feeding. In other words, these snappers averaged only about one game fish for every two meals. According to data obtained on snapping turtle populations in two lakes,this turtle averaged about two individuals for each acre of surface area. The average daily loss of game fish due to snappers in such waters might thus be one fish per acre. This is a very small part of the effect of the total predation pressure on the game fish population in any body of water and in itself is doubtless not a determiner of good or bad fishing.

Since the snapping turtle may account in part for poor catches by anglers on certain waters, perhaps thanks are due the commercial turtle hunters who are fast reducing the numbers of these slow-growing reptiles. On some waters, however, it is probable that a reduction of the numbers of sub-legal fishes by this turtle and other fish predators is beneficial to the angler. That a given body of water can produce only so many pounds of fish annually has been known by carp-culturists in Europe for more than a hundred years. If the fish are large, they will be few; if small, many. Predation may, by reducing numbers in some instances, be operating to give ultimately fewer but larger fishes to the angler.

Putting a baited turtle trap over the side.



When properly set, the hoops break water.

In regard to aquatic turtles other than the snapper, the data obtained for natural waters indicate that the greatest importance of these reptiles to game fishes probably lies in the competition they offer such fish for food. These turtles and fishes eat many of the same organisms such as insects, crayfishes, leeches, snails, clams, etc. No general statement regarding policy toward turtles can be made on this evidence, however, since the actual significance of turtles as food competitors is a thing which must be determined separately for each body of water. Similarly, predation by all of these turtles on eggs and fry, particularly on those of basses and sunfishes, must be analyzed for its local effects where it is found to occur.

Several considerations may be pointed out as balancing the possible deleterious effects which turtles may exert as competitors or predators of fishes. They provide a considerable amount of janitorial service in our lakes and streams. Dead and dying fishes and other animals as well as some domestic wastes are eaten

by them and thus prevented from littering bathing and resort beaches. In addition, these turtles are all edible (with the possible exception of the musk turtle) and constitute a source of food supply for man.

In spite of the scanty data on hand for turtles at fish hatcheries it may be stated that at such stations these animals hardly appear to be an asset. They may be trapped for removal to other waters by any of several means. A barrel may be sunk into the bottom of the pond and equipped with a "teetering board." Turtles which climb upon this board to bask in the sun literallty "walk the plank" and are tumbled into the barrel, from which they cannot escape. This type of trap works well for those turtles which habitually crawl out of the water to bask in the sun but for this reason excludes the more strictly aquatic ones such as the snapping, mud, and musk turtles. Many other kinds of effective traps may be designed to fit particular needs. For the most part they will be of two kinds--those which cannot be moved easily from pond to pond, such as the one just described, and those which can be moved more easily.

Ordinary fyke or hoop nets make effective turtle traps but are usually made of twine which will be torn by larger turtles. The conventional type of turtle trap is a modified fyke and may be purchased from dealers or made up to the following specifications (see photos):

NET:	Two-inch square mesh (or size suited to the kinds of turtles) of No. 24 linen seine twine.
LENGTH:	Four to five feet.
HOOPS:	Six gauge steel wire with welded joints, circular, three per trap.
THROAT:	Funnel shaped, eighteen inches deep from front hoop to opening, aperture one to two inches high by twenty inches wide; corners tied to middle hoop.
REAR END:	Closed by pursing string.
PRESERVATIVE:	Asphalt, applied hot to hoops and twine alike.
STRETCHERS:	Wood or nine-gauge steel wire; two for each trap.

Twine keeps best when tarred or barked. A marker float is attached to the trap by two or three feet of stout cord. Before setting such a trap a container filled with bait is suspended in the middle just inside the mouth. Effective containers are punctured tin cans and the best general bait is freshly killed fish. Watermelon rind is a very effective lure for soft-shelled turtles. Best results are obtained when traps are set so that the tops of the hoops are just out of water. In one of these traps as many as seventy-five turtles have been taken in a single night.

WASHINGTON, D. C.--Word has reached the Bureau of Fisheries of the successful arrival at Puno, Peru, on February 10, of a shipment of fish eggs sent by the Bureau from New York on January 26. A loss of only 7½ percent has occurred by the time the eggs were laid down in the Peruvian-Bolivian hatchery at Chucuito, according to Pedro Recavarren, Director of Agriculture at Lima.

The shipment consisted of some two million whitefish eggs and several hundred thousand lake trout eggs, destined to restock Lake Titicaca which lies 12,500 feet above sea level in the Andes mountains bordering Peru and Bolivia. The bulk of the eggs came from New York and Ohio hatcheries.

Dr. Gutsell weighing fish fed on his experimental diets at the Leetown Hatchery

THE FEEDING OF TROUT BROOD STOCK

THE DIET OF RAINBOW TROUT IN RELATION TO QUANTITY, QUALITY, AND COST OF EGGS

By James S. Gutsell
U. S. Bureau of Fisheries
Leetown, West Virginia

ALTHOUGH MANY fish-culturists have long held definite opinions on the best diet for trout brood stock - opinions doubtless based on hatchery experience - the writer is unaware of any published account of the effect of various diets on numbers or quality of eggs. The investigation described in this paper was undertaken for the purpose of determining the effect of heavy, medium, or light feeding of brood stock and of diets of varied composition upon the quality, numbers and cost of eggs. It should be emphasized that the results of these experiments, although extensive, warrant only tentative conclusions, having been obtained during a single year. Because of the evident practical importance and biological interest of the results here reported, however, it is planned to continue this study through several years, with a view to providing a check on the effect of particular diets or rationings continued through two or more years.

The most striking results obtained were the demonstration that light feeding of 3-year-olds is important not only for economical production of eggs but also

for the production of eggs of good quality. In the case of 2-year-olds or yearlings, however, there is no indication that heavy feeding adversely affects the quality of the eggs, although it seems always to increase the cost.

This report is based on 16 experiments carried out at the Leetown Fisheries station during 1938. In these experiments 1,500 rainbow trout were taken from mixed select lots and some 1,450 eggs were obtained from 662 of the fish. The fish were weighed and counted at monthly or four-weekly intervals for redetermination of the amounts of food to be given them. For each experiment with 3-year-old fish, 75 females and 25 males were placed in a circular pool 22 feet in diameter, and for each experiment with 2-year-old fish, 100 females and 50 males were placed in a pool of this same size. Smaller pools were used for yearlings.

Rainbow trout at Leetown, except for special strains and occasional individuals, spawn from early November to January, principally in November and early December. The age of trout at this station is reckoned from the year in which trout were fingerlings. Thus, trout hatched in November or December 1936, or in January or February 1937, after passing the fry stage are considered fingerlings through 1937, yearlings through 1938, 2-year-olds through 1939, etc. This practice is followed in this report, except that for the sake of simplicity spawners which are reckoned a given age when spawning began in the autumn are considered the same age through the spawning season, even into the next calendar year. However, few lots of eggs were taken after December 21 and only one (January 16) after December 31.

The mortalities noted (unless otherwise stated) are those recorded from the beginning of the experiment until the final weighing. Besides these, some fish jumped from the pools and were thus lost, and some were removed by unknown means. The numbers of fish in the various experiments at the beginning (June 8 or 17) and end (October 27 or November 3) of the restricted feeding period are shown in the second column of table 2.

The term "spawner" is used in this report to indicate a female trout from which eggs were obtained. Newly taken eggs are termed "green eggs," those with plainly eyed embryos, "eyed" eggs." They were measured (volume in fluid ounces) or sometimes counted after "shocking" or pouring to cause the bad eggs to turn white so they may be readily picked off.

The estimates of number or volume of eggs "per pound of parent" were obtained by dividing the average number or volume of eggs per spawner by the average weight of fish in any particular experiment at the last weighing. Because these egg-producing females probably were above the average weight, the figures for number or volume of eggs per pound of parent presumably are higher than they should be. However, it may be assumed that the ratio between the average weight of spawners and the average weight of fish generally did not vary greatly and that the data as here determined are therefore of good comparative value. In the case of the lots of lighter yearlings (especially Experiment No. 16) the difference between average weight of spawners and average weight of fish may have been much greater proportionally than in other cases. This would explain the apparent high yield per pound of parent (Experiment No.16) which is so out of line with the other results.

Figures for costs of eggs are based solely on the costs of food, both as given to the entire lot or as supposed to have been taken by the spawners only. For the older fish, these are based on the full experimental feeding period of about eight months (table 1). For yearlings, figures based on about four and a half months of feeding are the best available. To make possible comparisons between yearlings and older fish (table 2) the costs of eggs from the older fish were also calculated on the basis of a corresponding period of about four and a half months.

Except for the small amount of beef pancreas used in Experiment No. 16, the meat used in these experiments was sheep liver or sheep plucks.

EFFECTS OF OVERFEEDING, NORMAL FEEDING AND UNDERFEEDING (Experiments 1, 2,and 3)

Diet

Item	Percentage
Sheep liver	60
Dried buttermilk	9
Seal meal	9
White fish meal	9
Salmon egg meal	9[1]
Alfalfa meal	3
Salt	1

Three lots of 3-year-old fish were each fed the same diet (liver, 60 percent; meals, 40 percent) but in such amounts that one lot received all the fish would eat (Experiment No. 1, overfeeding), the second lot, a little more than one-half as much in proportion to its weight as the first (Experiment No. 2, normal feeding), and the third lot about half as much in proportion to its weight as the second (Experiment No. 3, underfeeding).

The yields per spawner were highest for the overfed lot (2,733) and a poor third for the underfed lot (1,896). It is possibly significant that eggs were obtained from fewer (54) spawners of the overfed than of the normally fed (60) or underfed (57) lots. The total yield (table 1) was highest for the normally fed and lowest for the underfed lot. In the proportion of eggs found to be eyed, the underfed lot stood highest (80.7 percent), the normally fed lot a little lower (78.7 percent), and the overfed lot not only a poor third, but lowest of all the lots of 2-year-olds and 3-year-olds (70.4 percent).

Eyed eggs from the overfed lot cost more than four times as much as those from underfed and nearly three times as much as those from the normally fed. Eyed eggs from the normally fed lot cost half as much again as those from the underfed lot.

The volume of green eggs per spawner was greatest among all lots for the overfed fish (12.45 ounces) and, among these three lots, least for the underfed (7.27 ounces) and intermediate for the normally fed (10.1 ounces). In the size of eggs, the overfed led (219.44 per ounce), the normally fed were second (249.7 per ounce), and the underfed third (260.7 per ounce). In yields per pound of parent the underfed (3.55 ounces or 924.9 eggs) and normally fed (3.66 ounces or 923.6 eggs) fish were sensibly equal, considerably above the overfed fish (2.97 ounces or 652.2 eggs). Mortalities were low (3-5) in these three experiments.

THE EFFECT OF AN UNBALANCED DIET (Experiment 4)

Diet

Item	Percentage
Sheep liver	40
Wheat middlings	30
Meat meal	30

This experiment, designed to test the effect of an "unbalanced diet," was also confined to 3-year-old fish. The yield per female was good (2,447 or 2.56 ounces), but the total yield (122,354 eggs) (table 1) moderate, because eggs were obtained from only 50 fish. The proportion eyed (72.5 percent)[2] was low among the eggs from adult trout and little better than the proportion of eyed eggs from the overfed fish. Actually the quality of the eggs was decidedly poorer than the figure indicates, because considerable numbers of ruptured eggs ordinarily appeared with the sound ones, but were poured off after the mixing of ova and milt

[1] For about a month, late in the season, salmon egg meal was not available. During this time the dried buttermilk, seal meal, and fish meal were increased to 12 percent each.

[2] One lot, the identity of which was lost at "shocking," was omitted for calculation of the figures on eyed eggs.

and not measured (or counted). The size of eggs (255 per ounce) and the yield per pound of parent (923 or 3.6 ounces) were in line with preceding experiments, except for No. 1 (overfeeding).

In spite of the distinctly but not extremely low proportion of eyed eggs, the cheapness of the diet resulted in a low cost of eyed eggs, intermediate between that for the underfed (Experiment No. 2) and normally fed (Experiment No. 3) lots. In pounds of food required to produce a thousand green eggs, this diet and the normal feeding of the diet used in the first series were almost identical; but for eyed eggs, the unbalanced diet made a much poorer showing. (See table 1). The mortality was relatively high (10).

THE EFFECT OF FISH IN THE DIET (Experiment 6)

Diet Item	Percentage
Sheep plucks	58.0
Herring	24.0
White fish meal	7.0
Alfalfa meal	3.5
Dried buttermilk	3.5
Tomato pumace	3.5
Cod liver oil	0.5

Two-year-old trout were fed a diet that is in use at the Hackettstown, New Jersey, hatchery. Because of the high moisture content, this was fed on a high "as weighed" basis. The fish not only grew exceptionally fast but yielded many eggs (2,358 or 9.4 ounces per spawner) of the highest quality (90 percent eyed)[3] obtained from any lot. The number and volume of eggs per spawner, and the size of eggs, (250 per ounce) were greatest among 2-year-old fish, but in estimated volume (3.4 ounces) and number (857) of eggs per pound of parent, this lot was not especially high. As usual with heavy feeding, the egg yield was low in proportion to the amount of food, and the expense high. On a lower feeding basis, it is probable that the proportional return would have been higher, the cost lower and only the yield poorer. Mortality was low (3).

SEAL MEAL (Experiment 7)

One lot of 2-year-olds was fed a diet 40 percent of which was seal meal (manufactured by the Bureau of Fisheries from the carcasses of fur seals), the balance sheep plucks. The yield per spawner (1,690 eggs or 6.13 fluid ounces) was the smallest from any except yearlings. However, the yield per pound of parent (899 eggs or 3.3 fluid ounces) was nearly in line with the results from other experiments with fish older than yearlings and the proportion of eggs found eyed was good (78 percent).[3] Eggs were small (276 per fluid ounce). Growth was somewhat slow and mortality (13) the highest found. Because of the cheapness of the diet and the moderate rate of feeding, the cost of eggs was low, much lower than for other lots of 2-year-olds.

STRAIGHT SHEEP PLUCKS (Experiments 5 and 8)

Because of its reputation as a food for brood stock, a straight plucks diet was chosen as a control and was fed to one lot each of 3-year-olds and 2-year-olds. Because of the evident dislike of the fish for the lung tissue, the dry bases were reduced below those of other diets except underfeeding, but not enough to avoid waste or to bring down the "as weighed" basis to a moderate level. From the 3-year-olds, (Experiment No. 5), the number of eggs per spawner (2,862) was the

[3] One early lot, killed by direct sunlight, was omitted for calculation of these figures.

Table 1. Quantities and costs of food for full experimental feeding periods in relation to yields of green and eyed eggs from older fish.[1]

Experiment No.	Number of Eggs		Percentage eyed	Indicated pounds of food fed spawners per 1,000 eggs.		Indicated cost of food fed spawners per 1,000 eggs.		Eggs per pound of food to entire lot		Cost of food for entire lot per 1,000 eggs	
	Green	Eyed		Green	Eyed	Green	Eyed	Green	Eyed	Green	Eyed
1 (overfeeding)	147,578	103,952	70	7.32	10.40	$0.57	$0.81	76	54	$1.00	$1.42
2 (normal feeding)	151,384	119,150	79	3.20	4.10	0.25	0.32	192	150	0.40	0.51
3 (underfeeding)	108,063	87,209	81	2.05	2.55	0.16	0.20	287	231	0.27	0.33
4 (unbalanced diet)	122,354	72,811	72	2.98	5.01	0.16	0.28	180	107	0.31	0.52
5 (plucks)	148,848	108,635	76	4.13	5.66	0.40	0.55	136	99	0.74	0.98
6 (24% herring)	169,758	140,877	90	4.65	5.61	0.34	0.41	128	116	0.57	0.63
7 (40% seal meal)	109,886	85,050	78	3.29	4.26	0.20	0.26	143	112	0.44	0.56
8 (plucks)	143,415	121,352	86	3.95	4.66	0.38	0.45	106	89	0.92	1.08

[1]These periods were as follows: Experiment No. 1, February 24 to October 26;
Experiment No. 2, March 1 to October 26;
Experiment Nos. 3-7, March 3 to October 26;
Experiment No. 8, March 18 to October 26.

highest average from any lot and the volume of eggs per spawner second only to that from the overfed lot. The yield per pound of parent, size of eggs and proportion of eyed eggs were about average for the 3-year-old fish. From the 2-year-old fish (Experiment No. 8), the yield per spawner (2,276 or 8.7 ounces) was intermediate among 2-year-olds, but the number per pound of parent highest among fish older than yearlings and the volume of eggs per pound of parent higher than for any other lot.

The proportion of eyed eggs (86 percent) was high, but lower than for the eggs from the fish fed the diet 24 percent of which was herring. The green eggs from the two lots fed straight plucks cost more, in terms of food, than those from any other lot except the overfed one (Experiment No. 1). More expensive eyed eggs were obtained only from Experiment No. 1 and the lot of yearlings given the high liver (80-20) diet (Experiment No. 9). The very high cost was due partly to the heavy rations combined with selective feeding and partly to the high cost per pound of the food. It is impossible to say what results lighter feeding would have brought. Under the conditions of the experiment, however, the diet was very good, although in most respects not the best, but was prohibitively expensive. There was no mortality among the 2-year-olds, but among the older fish it was high (10).

VARIOUS PROPORTIONS OF DRY FOODS (Experiments 9 to 13)

Five lots of yearling rainbow trout, in 15-foot pools, were fed, to the same dry basis, diets consisting of liver and a special dry mixture combined in the following proportions:

	Diet	
Experiment No. 9:	Liver, 8 parts	Dry mixture, 2 parts
" " 10:	" 7 "	" " 3 "
" " 11:	" 6 "	" " 4 "
" " 12:	" 5 "	" " 5 "
" " 13:	" 4 "	" " 6 "

The standard dry mixture used in these experiments consisted of one part each of whitefish meal, salmon egg meal, meat meal, and dried buttermilk. During the single month late in the season when salmon egg meal was not available, the other meals in the mixture were increased equally to take the place of the missing salmon egg meal.

In yield per spawner, the lot receiving the 70-30 diet stood highest (2,396 eggs or 5.5 ounces), followed by the lot fed the 80-20 diet (2,126 eggs or 5.3 ounces), then by that fed the 60-40 diet (1,974 eggs or 4.6 ounces), next by that receiving the 50-50 diet (1,889 eggs or 4.5 ounces), and lastly by that fed the 40-60 diet (1,691 eggs or 3.7 ounces). Thus, with one exception, the yield per spawner in the various lots decreased according to the decrease in the proportion of meat in the diet and in the "as weighed" basis of feeding.

The proportion of eyed eggs was lowest among those from the 40-60 diet (63 percent). The eggs from the other lots varied remarkably little in this respect (70-73 percent eyed). The volumes of eggs per pound of parent were noticeably below those from older fish (2.3 - 2.8 ounces), but in numbers of eggs per pound of parent (1,007 - 1,222) only one lot was surpassed by any one lot of older fish. The size of eggs varied irregularly through the series, even though the largest eggs (402 per ounce) came from the first and the smallest eggs (459 per ounce,

Table 2. Comparative quantities and costs of food, for restricted feeding period,[1] in relation to the yields of green and eyed eggs from 3-year-olds, 2-year-olds, and yearling fish.

Experiment No.	Number of fish		Number of spawners	Average final weight of fish in pounds	Number of eggs per pound of parent	Ounces of eggs per pound of parent	Eggs per ounce	Eggs per spawner		Percentage eyed	Indicated pounds of food fed spawners per 1,000 eggs		Indicated cost of food fed spawners per 1,000 eggs	
	Beginning of period	End of period						Green	Eyed		Green	Eyed	Green	Eyed
1 (overfeeding)	96	93	54	4.19	652	3.0	219	2,733	1,925	70	4.88	6.94	$0.37	$0.52
2 (normal feeding)	98	95	60	2.76	924	3.7	250	2,523	1,986	79	2.08	2.67	0.16	0.20
3 (underfeeding)	96	94	57	2.05	925	3.6	261	1,896	1,530	81	1.21	1.49	0.09	0.11
4 (unbalanced diet)	91	86	50	2.65	923	3.6	255	2,447	1,719	72	1.92	2.65	0.10	0.14
5 (plucks)	91	85	52	3.11	920	3.8	244	2,862	2,089	76	2.65	3.63	0.26	0.35
6 (24% herring)	145	140	72	2.75	857	3.4	250	2,358	2,151	90	2.80	2.99	0.20	0.22
7 (40% seal meal)	138	126	65	1.88	899	3.3	276	1,690	1,480	78	2.22	2.81	0.14	0.18
8 (plucks)	151	151	63	2.24	1,016	3.9	262	2,276	1,926	86	2.71	3.20	0.26	0.31
9 (80-20)	74	73	28	2.04	1,042	2.6	402	2,126	1,502	71	2.60	3.68	0.23	0.33
10 (70-30)	74	74	29	1.96	1,222	2.8	438	2,396	1,719	72	2.01	2.81	0.17	0.24
11 (60-40)	75	73	21	1.96	1,007	2.4	425	1,974	1,380	70	2.00	2.86	0.16	0.23
12 (50-50)	75	74	30	1.81	1,044	2.5	417	1,889	1,372	73	1.80	2.48	0.13	0.18
13 (40-60)	74	74	33	1.59	1,064	2.3	459	1,691	1,058	63	1.74	2.78	0.12	0.19
14 (40% herring)	63	61	18	1.57	1,102	2.5	448	1,731	1,330	76	2.57	3.38	0.15	0.19
15 (control)	62	61	14	1.19	1,300	2.9	456	1,547	1,055	68	1.94	2.84	0.16	0.2[illegible]
16 (70% soy beans)	54	54	16	0 57	1,446	3.3	442	8 824	584	71	2.32	3.02	0.10	0.15

[1]These periods were as follows: Experiment Nos. 1-8, June 9 to October 26;
Experiment Nos. 9-16, June 18 to November 2.

smallest average size from any experiment) from the last of the series. The eggs from the lots receiving the 50-50 and 40-60 diets were decidedly cheaper than those from the other lots of the series, and the eggs from the lot receiving the 80-20 diet much the most expensive. Mortality was low (0-1) among the fish fed these diets.

40 PERCENT HERRING DIET (Experiments 14 and 15)

One lot of yearlings (Experiment No. 14) was fed a diet 40 percent of which was herring (plucks, 4 parts; herring, 4 parts; meat meal and dried buttermilk, 2 parts). As a control on the effect of the herring in this diet, another lot was fed a diet consisting of 6 parts of plucks and 4 parts of the meat meal and dried buttermilk mixture (Experiment No. 15). These two lots were in 12-foot pools and were somewhat more concentrated than the fish of the preceding yearling experiments.

Because of the exceptional growth of the other lot (Experiment No. 6) receiving fish and the superior growth of this lot over the control, it is thought that the rather small size (in comparison with fish receiving a low meal diet in the preceding series) at spawning time was not due to a lack of nutrients in the herring item of diet, but in part, at least, to the smaller pool size, the higher fish concentration, the possible inferiority of the meal mixture, or to a combination of two or all of these factors. The small size of the fish would account for the rather small yield (1,731 eggs or 319 ounces per spawner for the fish-fed lot; 1,547 eggs or 3.4 ounces for the control). Although the yields per fish were comparatively low, the yields per pound of parent were not so low (1,102 or 2.5 ounces for the lot fed herring and 1,300 or 2.8 ounces for the controls). The eggs were a little smaller (448 and 456 per ounce) than those from most lots of yearlings. The proportion of eyed eggs (76 percent) from the fish receiving herring was the highest among eggs from any lot of yearlings, and decidedly higher than the proportion of eyed eggs (68 percent) from the control.

The cost of the green eggs from Experiment No. 14 was rather low among the yearlings and the cost of eyed eggs noticeably so. The eggs from the control lot, especially the eyed eggs, were more expensive. The mortality among the fish receiving the herring, although heavy later, was not high (3) during the regular experimental period. In the control only one dead fish was found.

SPROUTED SOY BEANS (Experiment 16)

The last lot, (Experiment 16), a small one in a 12-foot pool, was given a 70-30 diet like that used in the first series of yearling experiments (Experiment 10) but with the liver supplanted by ground, sprouted soy beans and a little beef pancreas added (soy beans, 7 parts; dry mixture, 3 parts; pancreas added at about the rate of 1 ounce to 10 pounds). Although the fish made very little growth, and being so very small, produced few eggs (824 or 1.87 ounces per spawner), most of these were of fine quality. Except for one very poor lot, the eggs averaged 75.4 percent eyed and frequently showed reddish coloring (average of all egg lots, 71 percent eyed). Moreover, the estimated numerical yield of eggs per pound of parent (1,446) was the highest obtained from any lot, and the estimated volumetric yield per pound of parent (3.3 ounces) high enough for older fish and much higher than for any other lot of yearlings (see page 20). There was no loss from June 17 to November 3.

CONCLUSIONS

It is emphasized that this report is based on one year's work only and therefore the effect of particular diets and of heavy, medium, or light feeding through two or more years cannot be taken into consideration. However, from these experiments and until more information is available, certain tentative conclusions as to the feeding of brood stock seem justified. Those judged of more immediate practical interest are given first.

1. Underfeeding through eight months preceding spawning is not harmful to the quality (fertility-viability) of eggs.

2. Although good eggs were obtained from heavily fed yearlings and, using a high meat diet and high meat and fish diet, very good eggs from 2-year-olds, it appears that overfeeding older fish (3-year-olds) a good 60-40 diet definitely reduces the average quality of eggs.

3. Starting with a very low level, not taking into consideration the subsequent condition of the brood stock, and in so far as the cost of eggs is based on the cost of food, increased feeding means increased cost of eggs.

4. Therefore, on this basis, eggs are most economically produced by a low level of feeding, with no reduction in egg quality.

5. Including meals, even a good combination of meals, to the extent of 60 percent of the diet, although it results in cheap eggs, appreciably impairs the quality (fertility-viability) of eggs, but 50 percent through seven months is not harmful. In the case of the "unbalanced diet" (middlings 30 percent; meat meal 30 percent), the apparent proportion of eyed eggs was fairly good but this does not take into consideration the large numbers of ruptured eggs poured off before the eggs were measured.

6. Fish (Pomolobus) in the diet, although dangerous to the brood stock in too high proportions, apparently tends to improve the quality of eggs of rainbow trout.

7. Straight sheep plucks heavily fed are not an outstanding food for brood stock. The resulting quantity and quality of eggs were very good, but not always the best. The cost of eggs was high. With lighter feeding, the showing might be much better.

8. From the standpoint of egg quality (fertility-viability) sprouted soy beans are a successful and cheap substitute for liver. Disadvantages in addition to the labor, attention, etc., involved, are the extremely slow fish growth and the consequent small number of eggs per spawner.

9. Eggs from yearling rainbow trout (approaching two years of age) were inferior (in fertility-viability) to those from 2- and 3-year-old fish but of a decidedly satisfactory quality. An expectancy of 70 percent eyed is indicated under local conditions. Eggs from 2-year-old rainbow trout (approaching 3 years of age) under local conditions are at least as good as those from fish a year older.

10. A yield of 1,000 or more per pound of parent is indicated for yearlings and about 925 (850 to 1,000) per pound of parent for 2-year-olds and 3-year-olds (except for overfed fish). Yields from yearlings may run as high as 1,445 per pound of parent from considerable numbers of fish. However, unless the number of females in a lot of yearlings can be determined, the total yield from such a lot will be very uncertain.

11. The proportional volumetric yield from 2-year-old and 3-year-old fish, on the other hand, definitely increases over the yield from yearlings, as from 2.5 (for yearlings) to 3.5 fluid ounces (for older fish) per pound of parent. Overfed 3-year-olds with 3 ounces per pound of parent were noticeably below this

standard for the older fish. Among yearlings, the most glaring exception appeared to be the small fish fed sprouted soy beans instead of meat with 3.3 ounces per pound of parent (but see page 20).

12. The size of eggs is dependent upon a number of factors. Among fish of the same age, the size of the eggs varies roughly according to the size of the parent. Thus, among 3-year-olds, the eggs of largest average size came from lots of the largest fish, the eggs of smallest average size from the lot of smallest fish. This applies also to 2-year-olds. There was a similar tendency among yearlings, but discrepancies were more marked.

13. Increased feeding means increased egg size. This is shown by Experiments No. 1, 2, and 3, which show an average of 219 eggs per fluid ounce from the overfed fish, 250 per ounce for the normally fed, and 261 per ounce for the underfed. Moreover, in all these experiments, the differences in average sizes of parents of the same age were mainly due to differences in growth during the current season and therefore to the amount of nourishment received. Therefore, among fish of the same age and previous treatment and growth, feeding during the current year may be taken as the principal influence on the size of eggs.

14. As between yearlings and older fish, age evidently is most important in determining egg size. Thus yearlings of a given weight yield much smaller eggs than 2-year-olds or 3-year-olds of the same weight. (Compare Experiment No. 3 with Experiments No. 9, 10, and 11, and Experiment No. 7 with Experiment No. 12, table 2).

15. Two-year-old and three-year-old fish of equal size yield eggs of equal average size (Compare Experiment No. 2 with Experiment No. 6, table 2).

16. Eggs were obtained from a considerably higher proportion of the 3-year-old than of the 2-year-old females.

COLUMBUS, OHIO.--With CCC labor, there have now been constructed approximately ten ponds, averaging about one and a half acres, at the new Federal fish-rearing unit at Senecaville. This unit is below one of the dams which control the water supply in the Muskingum Conservancy District. The ponds will be utilized for the production of bass and other pondfishes for stocking the waters of the District.

The pond system will be used for rearing purposes only, the small fish being transferred this year from the Bureau's hatchery at Rochester, Indiana. Next year when the Hebron, Ohio, station is in operation fry will be transferred from that point. They will be held in the ponds and reared until September or October when they will be released, at which time they should be from four to five inches in length.

HARRISBURG, PENNSYLVANIA.--With the completion of the pond system at Lock Haven, the output of the Lamar Federal hatchery will be increased approximately three hundred percent for the production of rainbow and brook trout. Assistance in the construction of these new bass and trout ponds is being given by the Civilian Conservation Corps. The several acres that will be devoted to bass ponds will be utilized for the production of large and smallmouth bass. This will be an innovation for this section of the State, since at the present time these species are not now produced by the Bureau in Pennsylvania for distribution.

THE PROTEIN REQUIREMENT OF TROUT

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FOODS COMMONLY USED in trout hatcheries have a high protein content. Meat products, dried milk, fish meal, and cottonseed meal are all known as protein concentrates. Trout fed diets composed of such ingredients will not suffer from protein deficiency. However, the protein is the most costly nutrient of the diet and efforts to reduce the food cost of trout production are usually associated with substitution of less costly carbohydrates such as cereal by-products. In making such substitutions it is assumed that trout will utilize the carbohydrates to some extent, although if not utilized the carbohydrates would still reduce the protein content since they would serve as bulk. To what extent the protein of trout diets can be replaced with carbohydrates and still yield maximum growth depends upon the degree of utilization of the carbohydrates, the quality of the protein in the diet, and the quantity of protein required by trout.

The protein requirements of higher animals have been studied extensively for nearly a hundred years. Many of the vital problems remain unsolved. Many attempts have been made to evaluate proteins in relation to such functions as growth, reproduction, maintenance and milk secretion. The methods used have been discussed critically by Boas-Fixen.[2] Three principal methods have been recognized. In the first the animal is fed a known weight of food and the increase in body weight is recorded. From such data the ratio of the increase in body weight to the weight of protein ingested can be measured. The gain in weight per gram of protein fed can be calculated. If the diet contains a low level of protein there may be only enough for maintenance with no gain in weight. As the protein level and the amount ingested increase, the growth increase per gram of protein increases to a maximum. At this point the animal is eating an excess protein for building body tissues and merely burns the excess. Thereafter the higher the protein level the lower the factor for utilization.

This method can be employed with trout but it assumes that the other constituents of the diet mixed with the protein are utilized to the same extent and that the diet is adequate for growth in vitamins, minerals, fats and calories. Great difficulties are encountered in evaluating the remainder of the diet for trout and grave errors may result. Thus it is easy to feed rats diets containing 10 and 20 percent protein and supply a carbohydrate such as starch to make up the remainder necessary to aggregate 20 percent. The rat utilizes starch well. If two rats are fed the same weight of diet daily there is little danger that the

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[1] Abstracted from the Annual Report of the Cortland Hatchery to the Division of Scientific Inquiry, U. S. Bureau of Fisheries. The hatchery is a cooperative project operated by the following, who jointly prepared the report: A. V. Tunison and A. M. Phillips, New York State Conservation Department; C. M. McCay, Cornell University; and C. R. Mitchell and E. O. Rodgers, U. S. Bureau of Fisheries.

[2] Fixen, M. A. B.
1934-35. Critical Study of Protein Evaluation. Nutr. Abstr. & Rev. 4, p. 447.

lower level of protein will introduce a calorie deficiency due to poor utilization of the carbohydrate. However, such an error may occur in the case of trout because the utilization of starch has not been sufficiently studied.

The second method of studying proteins involves the analysis of the bodies of animals at the beginning to establish their content of protein. Other animals of the same size and supposedly of the same composition are then fed proteins at different levels. The amount of protein ingested is measured carefully. After a given time the animals are killed and analyzed. From these data the amount of protein built into the bodies of the animals from that supplied by the diet can be measured.

The third method consists in analyzing the feed ingested and the excreta of animals during a growth period. From the difference the protein built into body tissue can be determined.

The first two methods are especially applicable to trout while the third method is very difficult to apply to fish. The following studies represent advances but are subject to errors due to our lack of knowledge concerning the utilization of starch by trout and concerning their vitamin requirements.

McCay and coworkers[3] conducted a series of experiments in 1931 to determine the protein requirements of trout. They concluded that this requirement was 14 percent or slightly higher. During the past year this study was continued in order to define more clearly the protein needs of the growing trout body. Brook trout fingerlings were used for the experiment and during its course these fish had a range in weight of 0.71 to 3.32 grams. Diets were designed to contain 5, 10, 12, and 16 percent of protein. The ingredients of the diet were dextrin, starch, salt, and fresh pig spleen which was used as the source of protein. Four groups of trout were fed these diets for a period of 24 weeks and at the end of this time three samples of trout were taken from each group for body analyses. The results of the chemical analyses are presented in table 1.

These data were treated statistically by means of analysis of variance, and the differences between the protein per trout as affected by the level of protein in the diet were found to be significant, the least difference being 0.029 grams of protein. This is obvious without statistical treatment. In the case of the fat content per fish the least difference was 0.01 grams showing that there was no difference between the fish at the start of the experiment and those that had been fed a diet containing 5 percent of protein for a period of 24 weeks. The difference is significant between the other groups.

The trout were weighed at periodic intervals throughout the course of the experiment and at the close of the study the four groups had made the following gains in weight, expressed as an average percent of the body weight for four-week periods; 5 percent level, 7 percent; 10 percent level, 17 percent; 12 percent level, 20 percent; and 16 percent level, 29 percent. The mortality decreased as the percentage of protein was increased in the diet, being 2.1, 0.85, 0.65, and 0.42 percent expressed as an average percentage for 2-week periods.

Although the diets were designed to contain 5, 10, 12, and 16 percent protein, analyses of samples of the fresh pig spleen taken during the course of the experiments showed that actually the average percentage of protein in the four diets was 4.8, 9.7, 11.6, and 14.6. All groups of trout in the experiment were allowed the same amount of food each day in proportion to their body weight. Calculation shows that the four groups had the following grams protein allowance per kilo per day: 5 percent level, 2.54; 10 percent level, 4.38; 12 percent level, 4.97; and 16 percent level, 5.77.

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[3] McCay, C. M., et al.
1931. The Nutritional Requirements of Trout and Chemical Composition of the Entire Trout Body. Trans. Amer. Fish. Soc., Vol. 61, p. 58.

Table 1. Chemical analyses of trout bodies fed diets containing 5, 10, 12, and 16 percent protein for a 24-week period.

Percentage protein in diet	Number of fish in sample	Average dry weight of fish (grams)	Percentage protein	Grams protein per fish	Percentage fat	Grams of fat per fish
5	86	0.221	63.94	0.141	5.57	0.012
	90	0.204	63.87	0.130	5.31	0.011
	82	0.227	65.44	0.148	4.82	0.011
	Average	. . .	. . .	0.140	....	0.011
10	43	0.435	65.31	0.284	8.80	0.038
	54	0.376	62.94	0.236	8.01	0.030
	50	0.405	64.94	0.262	7.88	0.032
	Average	. . .	. . .	0.261	....	0.033
12	38	0.552	63.87	0.352	9.88	0.055
	42	0.526	61.87	0.326	10.67	0.056
	40	0.493	63.87	0.314	8.93	0.044
	Average	. . .	. . .	0.331	....	0.052
16	30	0.794	63.37	0.503	12.24	0.097
	28	0.840	62.62	0.526	11.86	0.100
	27	0.840	61.62	0.519	12.83	0.108
	Average	. . .	. . .	0.516	....	0.102
Trout at beginning of experiment.	256	0.128	66.06	0.085	10.21	0.013
	296	0.129	67.06	0.087	9.38	0.012
	303	0.132	66.19	0.087	9.41	0.012
	Average	. . .	. . .	0.086	....	0.012

Table 2 indicates that trout are similar to higher animals inasmuch as the content of the body in protein tends to remain relatively constant. This indicates but a slight storage of nitrogenous constituents. If the diet is adequate, the body fat also seems to be relatively constant at a level of 8 to 10 percent. The diet with the lowest level of protein probably provides inadequate calories for satisfactory growth and maintenance, therefore the body fat approaches the minimum.

Table 2. Relation of protein level in the diet to conversion into body protein.

Protein level	Percentage protein converted into body protein	Increase in grams of live weight per gram of protein fed	Percentage of calories of diet converted into body calories
5	9	0.8	1
10	15	1.2	3
12	17	1.3	4
16	22	1.6	9

The lowest level of protein that a ration can contain and permit optimum growth depends upon the quality of the protein. For young swine this amounts to about 18 percent. For chickens it may be slightly higher during the first 8 weeks. For rapidly growing rats 18 percent may represent the requirement for a protein of medium quality such as wheat gluten.

In the case of rats, various workers have found from 1 to 2 grams of living body could be produced from a gram of protein, depending upon the quality of this protein. Using the technique of analyzing the entire animal body, rats can build from 20 to 38 percent of the protein they eat into body tissues. Limited studies with insects have indicated that they can build as much as 60 percent of their food protein into the nitrogenous constituents of their bodies.

Table 2 contains summaries of these data with trout. They indicate that the values for the conversion of protein are comparable to those found with warm-blooded species such as the rat. In fact, these data probably are well below the true values because of protein losses in the water during feeding. No satisfactory method has been found to measure these losses. Therefore the trout compares favorably with higher animals with respect to protein conversion. In hatcheries that feed meat only, fair estimates of this conversion can be made by taking the values given for the composition of the trout body and assuming a mean value for meat.

NORFOLK, VIRGINIA.--With a view to obtaining additional information on the seasons at which eastern trout may be planted with best results, 1,000 rainbow trout about 8½ inches long were recently planted in North Creek in Jefferson National Forest near Natural Bridge, Virginia.

This experiment is the third one of its kind which has been inaugurated by the Bureau of Fisheries to determine just what proportion of hatchery fish so planted will eventually reach the angler's creel. The oldest test stream, in Vermont, will be operated again this year.

The results of this test and the similar management program in streams of the Pisgah Game Preserve (North Carolina) are encouraging, Bureau investigators report. The streams contain many more trout this spring than at any time since the work was undertaken. Much natural spawning of both brook and rainbow trout was observed in the streams during the past fall and winter.

SEATTLE, WASHINGTON.--The Big White Salmon substation of the Bureau of Fisheries is feeding 7,570,000 chinook salmon fingerlings and 190,000 rainbow and brook trout fingerlings. Two million chinook salmon fingerlings were planted during the month in Spring Creek.

The employees of this station assisted the personnel of the Little White Salmon substation in releasing several million chinook salmon fry from the Little White Salmon station: 11,343,000 advanced chinook salmon fry in the Little White Salmon river; 7,105,000 in the River above the hatchery; and a remaining 4,238,000 in the pool at the hatchery.

In addition, 475,000 eyed rainbow trout eggs were received from the Washington Department of Game for hatching and subsequent transfer to the Leavenworth, Washington station.

A TREATMENT FOR TAPEWORMS IN TROUT

By Donald L. McKernan
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A TAPEWORM INFESTATION of hatchery trout was recently brought to the attention of the Bureau's Pathology Laboratory at Seattle by Mr. Clarence Pautzke, Chief Biologist for the Washington State Game Department. The infestation occurred among yearling rainbow and steelhead trout at one of the State hatcheries near Seattle. Through the courtesy and cooperation of Mr. Pautzke, and with the aid and advice of Les Walters, Washington State Hatchery Superintendent, an opportunity was afforded to test the possibility of removing the tapeworms from the intestines of these fish by the use of the common vermifuge, kamala. Dr. Frederic F. Fish, Associate Aquatic Biologist, contributed valuable suggestions as to the methods for testing the efficacy of kamala.

The tapeworm, apparently an undescribed species of the genus Proteocephalus, was found to be present in about fifty percent of the yearling rainbow trout at this hatchery. As a tapeworm of the same genus (P. ambloplitis) presents a serious problem at many bass hatcheries, the development of an effective control measure for tapeworms of this group would be highly desirable.

Kamala, the vermifuge used in this experiment, is obtained from the glands and hairs present on the capsules of an East Indian shrub. It has been widely used as an effective taeniafuge for various animals.

The first two experiments (A and B) were conducted at the University Experimental Station. The infested fish, which measured from three to six inches in length, were brought from the hatchery to the experimental station and kept in troughs for the duration of the experiment. In experiments A and B, kamala was thoroughly mixed with fresh beef liver and fed once or twice daily. The fish were held in the troughs about one week prior to treatment so they would become accustomed to their surroundings and also to provide a check on the possibility that the fish would expel the tapeworms without any treatment other than a change in the environment.

The fish were starved three days before treatment so they would eat the medicated food readily. Likewise, after the period of treatment, the fish were again starved three or four days before killing to facilitate examination of the intestines.

The technique employed for Experiment C, carried on at the hatchery, was essentially the same as that of the foregoing experiments, A and B, the principal difference being that a third trough of infested fish was included as a control group. The purpose of the control group was to ascertain whether the tapeworms would be removed by causes other than the vermifuge. In Experiment C three troughs were each stocked with 200 infested fish. The experimental fish were fed once daily four percent body weight of the standard hatchery diet containing kamala which had been thoroughly mixed with the food by hand. Trough No. 1 was fed food containing one and one-half percent kamala by weight; trough No. 2 was fed two percent; and trough No. 3 - the control - was fed only untreated food. All three troughs were examined daily and any tapeworms present on the bottom or caught in the screen were preserved. As the tapeworms were usually broken when found, it

[1]Contribution from the University Experiment Station, a cooperative experimental unit maintained by the U. S. Fisheries Pathology Laboratory, Seattle, Washington, and the School of Fisheries, University of Washington.

was impossible to make an accurate day-by-day count of the total number of tapeworms expelled by the fish. After being fed the vermifuge for one week, the fish were starved for two days, and a random sample of twenty-five to thirty fish from each trough was preserved in ten percent formalin for subsequent intestinal examination. The water temperature remained constant throughout the week at 46° F.

The results of these experiments are tabulated in table 1.

Table 1. Efficacy of various concentrations of kamala in removing tapeworms (Proteocephalus sp.)

Experiment	Trough No.	Percentage concentration of kamala (by weight)	Number of fish used	Percentage of fish infested before treatment	Duration of treatment	Percentage of fish infested after treatment	Percentage of mortality during treatment
A	1	1	30	75.0	One week	0.0	3.33
	Uninfested control	1-5	15	--	Two weeks	---	0.00
B	1	2	8	50.0	One week	0.0	0.00
C	1	1.5	200	51.7	One week	0.0	12.00
	2	2.0	200	51.7	One week	0.5[1]	5.00
	Infested control	---	200	51.7	One week	51.7	9.00

[1] One disintegrated fragment.

DISCUSSION

Experiments A and B were designed to establish the value of kamala as a vermifuge for fish tapeworms and to determine the toxicity, if any, of kamala concentrations up to five per cent. The result of experiment A indicates that one percent kamala is effective in removing all Proteocephalus sp. from trout. The uninfested fish in Experiment A, which were fed percentages of kamala gradually increasing from 1 to 5, even when fed as high as five percent kamala for two weeks showed no ill effects.

In Experiment B, the fish were fed two percent kamala for one week. All tapeworms were expelled by the fish during the first three days of treatment. This would seem to indicate that the two percent concentration may be a more rapidly acting treatment than a one and one-half percent concentration.

In Experiment C, tapeworms appeared in both troughs--one being fed one and one-half percent, and the other two percent kamala--on the same day. The number of tapeworms appearing in the troughs reached a maximum three days after the start of the treatment and subsequently decreased until on the sixth day but one tapeworm was passed by the fish in each trough. No tapeworms were found on the seventh day. On examination after treatment, an estimated 51.7 percent of the fish in the control trough were found infested with tapeworms. All treated fish were completely free from parasites, except for one partially disintegrated section of tapeworm consisting of about six proglottids. The tapeworm fragment undoubtedly was dead, but had not been expelled before this fish was preserved. No parasites were passed by the control group of Experiment C during the experiment.

It appeared that the tapeworms, when numerous, inflicted some damage on the trout. Fish three inches in length often carried as many as five large worms varying in length from fifty to ninety mm. in their intestines. In many of the smaller "runts," the tapeworms had formed an obstruction which obviously prevented easy passage of the food through the intestines, and which resulted in a large distention of the intestine just posterior to the pylorus. It is probable that the growth of the fish would be inhibited by Proteocephalus sp., especially if the worms are acquired when the fish are small. The degree of infestation ranged from one to five worms per fish - with an average of two.

The bass tapeworm, P. ambloplitis, is reputed to cause partial or complete sterility of brood stock at many bass hatcheries. Since the life cycle of the bass tapeworm is completed within the hatchery pond, if the mature tapeworm could be expelled from the adult bass before they are placed in the spawning pond subsequent infestation of the young bass by the plerocercoid stage of the tapeworms could not occur. Presumably, if the brood bass could be fed kamala mixed with food, or by stomach tube if necessary, P. ambloplitis could be eliminated from bass hatcheries. Whether the exact percentage effective in removing Proteocephalus sp. from trout would be effective against P. ambloplitis in bass is questionable. However, as seen from this series of experiments, even five percent concentrations of kamala are not toxic to trout and probably would be harmless to bass as well.

The cost of preparing one hundred pounds of two percent kamala-treated food is approximately $1.95. This would be sufficient to treat 4,160 fish averaging twenty fish per pound for a two-week period.

SUMMARY

From these experiments it is concluded that one and one-half to two percent kamala mixed with beef liver or other standard diets and fed for approximately one or two weeks may be relied upon to eradicate Proteocephalus sp. from trout. Facilities were not available for testing this vermifuge on black bass, but the same or a slightly different concentration of kamala may prove an effective means of preventing serious trouble in bass hatcheries resulting from infestations of P. ambloplitis.

ST. LOUIS, MISSOURI.--It is expected that this year output of the cooperative hatchery at St. Louis will exceed one half million fish. This unit, known as the Forest Park hatchery, is owned by the City of Stl Louis and operated by the Bureau of Fisheries. The City bears all maintenance cost while the Bureau's expenditures cover the fish-cultural operations.

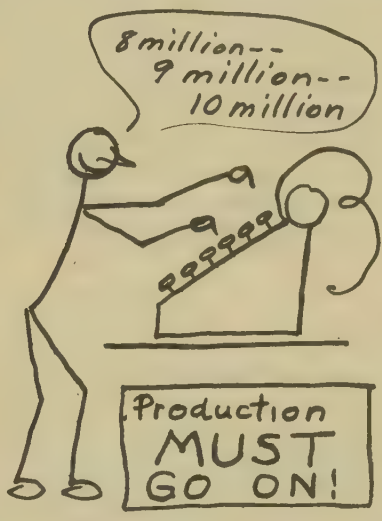
At a recent conference in St. Louis with members of the State fish and game conservation department, it was decided that a future meeting would be held for the purpose of working out a program for fish distribution so that the Bureau's operations at St. Louis and Neosho, Missouri, would not conflict with the stocking program of the State. It is believed that such a distribution of activities of the two organizations will save funds.

No Foolin'

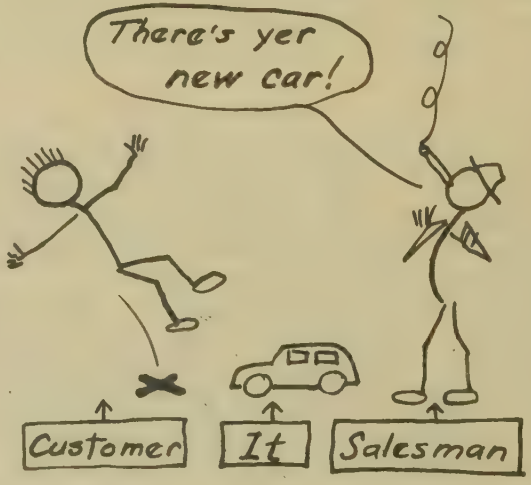
A Serious Subject Discussed In Lighter Vein

By A. Nonymous

FOR MANY YEARS I have been associated with the science of fish culture. I know fish-cultural methods thoroughly and have contributed not a little to their development. Now I am abandoning my career as a fish-culturist--am abandoning it from a sense of duty to society--for I believe that the organization and procedures of fish culture applied to industry will prove nothing short of revolutionary. I intend to manufacture automobiles. Let me explain to you how my methods will operate in the proposed application to the automotive industry.

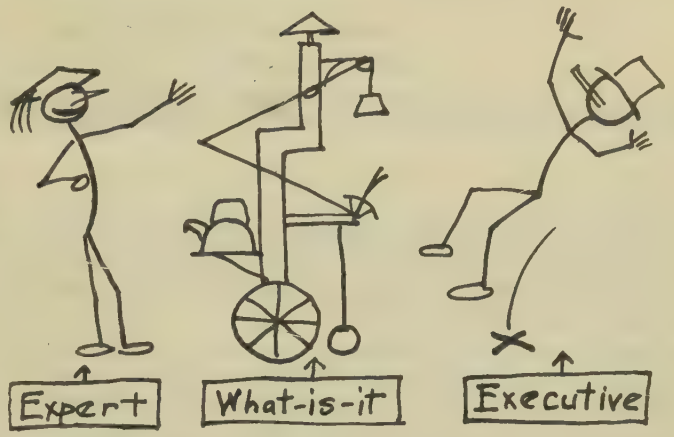


First the accounting system in the automobile industry is all wrong. In a hatchery when we want to figure the cost of rearing a No. 4 trout we simply determine the cost of food one fish will eat up to that stage, multiply by the number, and there you are. The accountants in automobile factories figure in such things as capital investment, depreciation, sinking funds, wages, and costs of transportation and administration. That makes the cost per unit far too high. In my factory costs will be figured strictly on the basis of the materials that go into each car. The stockholders will be overjoyed to learn how cheaply an automobile can be manufactured.



Planting eggs and fry has taught me a lot, too, on the matter of maintaining production. It's bad business to show a decline in output. Every year there must be an increase in the number of units. Just to make sure that production will always increase, I plan to install a department that manufactures 6-inch models with watch-spring motors. These little fellows may not solve the nation's

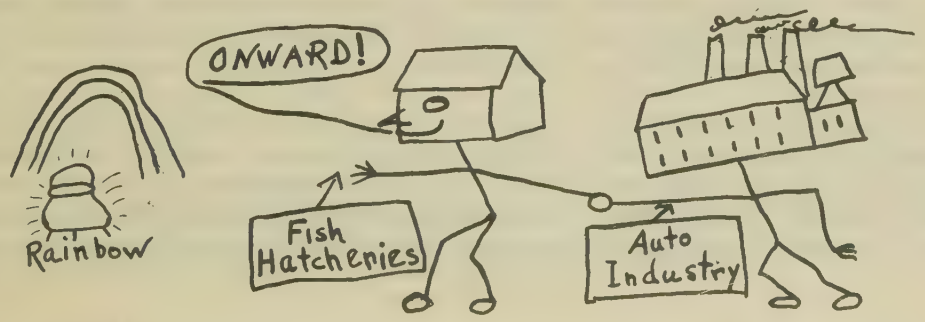
transportation problems but they are cars, nevertheless. They have four wheels and will run a few feet at least. Each one we make will cut down the average unit cost. The stockholders will find good reading in annual reports that always show a greater output at a decreasing unit cost.



Automobile manufacturers keep themselves in financial hot water by changing things too much and too often. The biggest mistake Ford ever made was when he quit producting Model T's. Just think of what the new equipment and reorganization must have cost in money and trouble. Thousands of workmen had to learn entirely new ways of doing things.

There won't be any technical experts or research engineers in my automobile factory. In my fish culture work I had contact with experts--fishery biologists. At first I thought they might help us a lot, but instead of finding answers to our problems they wrote reports on the incidence of progressive myopia in the squee-gee fish. Once in awhile one would go practical and let us know that fish have to eat if they are going to grow. A few even went so far as to travel around sticking a toe in this lake or stream and a finger in that one and drawing conclusions. They should have stopped in one place long enough to take a bath. No, I don't want any experts. If I had them they would probably spend their time developing steel tires for farm wagons and defrosters for aeroplanes.

We will avoid a great deal of work, worry, and expense by eliminating the check-up of cars and trucks after they have left our factory. When we have produced cars and trucks and moved them from the factory our work will be done. Where they go and how or even if they run will be no affair of ours as long as their wheels are turning when they leave the assembly line. Our job will be production. If the stockholders become fussy on the subject of dividends I'm fairly sure they can be quieted down by the figures in the annual report. If that won't turn the trick, I'm certain a picture of a few cars coming off the line will.



ABSTRACTS

TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY

BY SPECIAL ARRANGEMENT with the Executive Committee of the American Fisheries Society, the PROGRESSIVE FISH-CULTURIST is pleased to present herewith abstracts of a selected group of papers from the current Transactions of the American Fisheries Society (Volume 69, 1939). It is regretted that many stimulating and valuable papers had to be excluded because of space limitations. Out of the 35 papers included in the recently published volume of the Transactions, the editors of the PROGRESSIVE FISH-CULTURIST have chosen 11 which they believe will be of special interest to a wide group of the readers of this journal. In several instances the authors' abstracts as presented in the Transactions have been amplified slightly.

EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON PLANKTON PRODUCTION AND BLUEGILL BREAM CARRYING CAPACITY OF PONDS

E. V. Smith and H. S. Swingle
Alabama Agricultural Experiment Station
Auburn, Alabama

Small, excavated ponds were stocked with one-year-old bluegill bream (Lepomis macrochirus) in May, 1936, and drained in November. The number and total weight of fish in each pond were determined. Different ponds were fertilized with an inorganic fertilizer, laying mash, cottonseed meal, and cottonseed meal and superphosphate. Water samples were taken from each pond at intervals of two weeks throughout the season for quantitative and qualitative plankton determinations.

An unfertilized control pond had the lowest average plankton production and the lowest carrying capacity for bluegill bream. The pond fertilized with cottonseed meal alone had the next lowest average plankton production and the next lowest carrying capacity. The pond fertilized with laying mash produced an average plankton yield about one and one-half times as great as that fertilized with cottonseed meal, and the increase in carrying capacity for bluegills was of the same magnitude. Adding superphosphate to the cottonseed meal doubled the average plankton production and almost doubled the carrying capacity for bluegill bream. An inorganic fertilizer proved best, producing the greatest amount of plankton and fish.

When inorganic fertilizers were used the entire food supply of the pond was dependent upon the production of phytoplankton but when organic fertilizers were used, they were partly utilized directly by animal organisms and the phytoplankton phase was more or less omitted. Consequently, organic fertilizers may produce the same fish yields as inorganic fertilizers but at lower levels of plankton abundance.

FISH PRODUCTION IN TERRACE WATER PONDS IN ALABAMA

H. S. Swingle and E. V. Smith
Alabama Agricultural Experimental Station
Auburn, Alabama

Terrace-water ponds are being constructed in Alabama that have as their only source of water supply the "run-off" from terraced pastures and crop lands. The water level in the ponds fluctuates, and a maximum of 2 to 4 feet of water is lost by evaporation and seepage during extremely dry weather. A minimum depth of 10 feet in the deepest part of the pond is recommended in order to carry the fish population through dry periods.

The terrace-water ponds are being used successfully for the production of largemouth black bass, bluegill bream, and crappie. They can be fertilized successfully with commercial fertilizer as very little water is lost over the spillway during the growing season. One such fertilized pond, having a maximum area at high water of 1.5 acres and an average area of approximately 1 acre, was drained after three years; it was fished during the summer prior to draining. A total of 77 pounds of fish was removed by fishing and 580 pounds were taken from the pond when it was drained; of this poundage, 225 pounds were largemouth bass, and 284 pounds were bluegill bream. The remainder consisted of golden shiners and yellow bullheads. In another fertilized pond the catch of game and pan fish in one season was 94 pounds per acre.

FURTHER OBSERVATIONS ON THE FEEDING HABITS OF THE MONTANA GRAYLING (*THYMALLUS MONTANUS*) AND THE BLUEGILL (*LEPOMIS MACROCHIRUS*) IN FORD LAKE, MICHIGAN

Justin W. Leonard
Michigan Department of Conservation
Ann Arbor, Michigan

The feeding habits of a small population of Montana grayling in a small landlocked lake in northern Michigan are described in detail on the basis of stomach analyses of specimens taken in April, May, July and October, 1938, and March, 1939. The progress of the experiment based on these grayling was complicated by the unauthorized stocking of bluegills in the lake which, prior to the planting of the grayling, had been freed of all fish by treatment with rotenone.

As was noted in an earlier report on this experiment, immature and adult stages of certain predacious aquatic insects, notably Odonata and Coleoptera, occupied a most important place in the diet of the grayling. An interesting result of the presence of bluegills in the lake was the fact that by the time the grayling had attained an average standard length of 246.5 millimeters they began to prey upon small bluegill fingerlings. Data are presented to show that all but fingerling bluegills are direct food competitors of the grayling. Observations indicate that the effects of this competition are already resulting in a reduction of the grayling population. It is suggested as probable that the non-reproducing grayling will be unable to maintain satisfactory growth and viability in the face of continued competition from the prolific bluegills.

COPPER SULPHATE AND ROTENONE AS FISH POISONS

M. W. Smith
Atlantic Biological Station
St. Andrews, New Brunswick

In recent years both copper sulphate and rotenone (derris powder) have been used to destroy undesirable fish. A concentration of 3 p.p.m. of copper sulphate was effective in killing fish in the acid waters of four Nova Scotian lakes. The plankton and the bottom fauna were almost entirely destroyed. Rooted aquatic vegetation was largely unaffected. About a year elapsed before plankton and aquatic insects returned in quantity. Mollusks have not repopulated the lakes. Considerable copper remained in the waters for some time, but there was evidence that much was in a combined, non-toxic form.

Rotenone, as contained in derris and cube' roots, is toxic to fish in very low concentrations. At 5° and 20° C., concentrations of derris and cube' (5 percent rotenone) as low as 0.20 p.p.m. killed yearling trout. At 10° C., 0.20 p.p.m. of derris (3 percent rotenone) was toxic to suckers and lake chubs. In a small lake, 0.25 p.p.m. of derris (5 percent rotenone) killed eels, lake chubs, sticklebacks, black bass and white perch, but a few eels, lake chubs, and sticklebacks survived. Storing derris and cube' powders in a dry condition as long as three years did not affect their toxicity to brook trout. Increased temperature speeded greatly the action of rotenone (derris and cube' powders). Brook trout that had lost their equilibrium in water treated with rotenone revived in untreated water. Planktonic crustaceans were largely destroyed by concentrations of rotenone sufficient to kill fish in natural waters, but aquatic insects, mature and immature, mollusks, Hydracarina, certain rotifers, algae and rooted aquatics were not destroyed. In a small lake in which the original concentration of derris (5 percent rotenone) was 1.33 p.p.m. the water remained toxic to fish for approximately one month.

COMPARISON OF COHO SALMON FRY FROM EGGS INCUBATED IN GRAVEL AND IN HATCHERY BASKETS

G. Clifford Carl
Pacific Biological Station
Nanaimo, British Columbia

Eggs of coho salmon (Oncorhynchus kisutch) were planted in gravel, and placed in open and covered hatchery baskets in hatchery troughs to determine the possibility of the production of differences in eye diameter by incubation under the different conditions. No significant difference was found between any two of the three lots. In the gravel planting a number of eggs was unaccounted for, which may explain the high rates of efficiency obtained by basing estimates of losses in redds only upon the number of dead eggs remaining in the gravel.

AN EXPERIMENT IN HATCHING SILVER SALMON (ONCORHYNCHUS KISUTCH) EGGS IN GRAVEL

Leo Shapovalov and William Berrian
Bureau of Fish Conservation
California Division of Fish and Game

The eggs from five adult sea-run silver salmon (Oncorhynchus kisutch) were divided into two lots: 8,239 eggs were buried in gravel in a standard hatchery trough and 7,500 placed in a standard hatching basket as a control. Natural conditions were simulated as closely as possible with the gravel eggs. The eggs required 772.3 temperature units (t.u.) to maximum hatch (control), 1,084.3 t.u. to earliest emergence from the gravel, and 1,155.6 t.u. to maximum emergence from the gravel. Initial to final emergence required at least thirty-eight days. Of the eggs buried, 10.2 percent emerged from the gravel. In the control, 65.9 percent of the eggs hatched and 48.2 percent survived to the time that the experimental fish had finished emerging from the gravel. Examination of the gravel and the dead eggs in it at the conclusion of the experiment and observations made during previous experiments support the view that silt carried by unusually severe floods smothered many of the eggs in the gravel. This fact seems to account in large part for the small percentage of salmon emerging from the gravel. Fifty-six days after initial emergence from the gravel, the experimental fish averaged 23.8 fish per ounce (1.19 grams each, live weight) while the control lot averaged 27.6 fish per ounce (1.13 grams each). During these fifty-six days only forty-eight of the experimental fish died, whereas the mortality in the control lot for the same period totaled 905. In the final two weeks, however, the average daily mortality in the control was only one fish.

THE DECLINE OF THE PYRAMID LAKE FISHERY

Francis H. Sumner
Temporary Assistant, U. S. Bureau of Fisheries
Stanford University, California

The history of the Pyramid Lake (Nevada) cutthroat trout (Salmo henshawi Gill and Jordan) fishery, conducted by reservation Indians, shows a rapid decline in the catch within the last few years. While the Indian is blamed for overfishing, the white man's demand for trout, the dams and diversions that he built along the Truckee River where the trout have spawned, the pollutants that he has dumped into the river, the spawn that he has taken, the competing species of fish that he has introduced, and principally the large amounts of water that he has diverted to another watershed, have led to a condition which has prevented the trout from reproducing its kind. The revival of the fishery is made doubtful by an agreement concerning the use of the Truckee River's flow, the expense of hatching and rearing a stock of the Pyramid Lake trout (not to mention the questionable availability of its eggs), and inadequate regulation of the fishery. Thus, the Pyramid Lake cutthroat trout fishery appears to be doomed.

SCYPHIDIA MICROPTERI, A NEW PROTOZOAN PARASITE OF LARGEMOUTH AND SMALLMOUTH BLACK BASS

Eugene W. Surber
U. S. Bureau of Fisheries
Leetown, West Virginia

A small urn-shaped peritrichous protozoan, apparently an undescribed species, was found on the gills and bodies of largemouth and smallmouth black bass in ponds at Leetown, West Virginia. A heavy mortality among a lot of fingerling largemouth bass probably resulted from suffocation due to the organisms on the gills. Specimens of the parasite, preserved in formalin, measured about 57 microns in length and 24 microns in maximum width. The base of the animal consists of a circular disc about 6 microns in diameter. No evidence was found that the sucker-like attachment disc penetrated the epidermal cells of the host causing necrotic tissue. The anterior or upper end of the animal has a ciliary disc and two rows of cilia. The body is without cilia and is annulated. The macronucleus is very large, has the shape of an inverted cone and occupies much of the lower half of the body. The small micronucleus apparently lies in the slightly concave surface of the upper part of the macronucleus, although there is doubt on this point. This new species was named Scyphidia micropteri after Micropterus, the generic name of the smallmouth black bass, one of its hosts. The species recently was found by Dr. H. S. Davis on gills of largemouth black bass collected in Radnor Lake, Tennessee, which indicates a wide geographical distribution of the parasite.

NEASCUS INFESTATION OF BLACK-HEAD, BLUNT-NOSED, AND OTHER FORAGE MINNOWS

George E. Klak
U. S. Bureau of Fisheries
Leetown, West Virginia

Black-head, blunt-nosed, and other minnows were found to be infested with encysted larval flatworms in ponds at Leetown, West Virginia. Of the 5 species of minnows examined, only the golden shiners were free from infestation. Black-head and blunt-nosed minnows were most severely parasitized. The mortality in a 2.2-acre pond stocked with 100,000 black-head minnows was about 250 per day during 4 weeks of observation. Heavy infestation caused sterility in the minnows.

In the absence of the adult form of the parasite, complete identification has not been made, but it is believed to be a member of the family Strigeidae and the genus Neascus. The adult probably infests fish-eating birds, with snails and minnows serving as intermediate hosts to the successive larval stages.

Largemouth and smallmouth black bass apparently have a natural immunity to the Neascus parasite. Since the golden shiner is also immune, the substitution of this species for black-head minnows is contemplated at the Leetown station.

Control of snails in hatchery ponds and of fish-eating birds is suggested as a means of limiting the abundance of this parasite. Parasitized minnows should not be distributed to lakes and streams, nor should they be used for bait.

THE PRODUCTION OF RAINBOW TROUT AT PAUL LAKE, BRITISH COLUMBIA

C. McC. Mottley
Cornell University
Ithaca, New York

Three of the major problems connected with rainbow trout production and management were studied at Paul Lake, British Columbia: (1) what quantity of fish can be produced in a given body of water, (2) how big a crop can be removed and still allow a sustained yield, (3) how great a financial expenditure to increase production may be justified. The investigation covered a period from 1931 through 1936 in which a consistent stocking policy requiring the planting of 200,000 one-inch fry was carried out.

The total number of fish caught by anglers increased from 3,000 in 1932 to 10,000 in 1936; the total weight of fish caught from 4,500 pounds to 10,000 pounds; and the average weight of fish caught decreased from 1.5 pounds to approximately 1 pound. The number of fish in the spawning run increased from 500 in 1932 to 2,500 in 1936. Reports from the fishery for 1937 and 1938 indicate that the total catch is remaining at a fairly steady level of between 9,000 and 10,000 fish per year.

The data show that the lake was capable of producing about 10 pounds of trout per acre and that this amount is being maintained under the policy outlined. The mortality amounted to about 95 percent, providing a 5 percent yield to the fishermen. The cost of the stocking operations was judged to be commensurate with the return to the people of the Kamloops District. The Paul Lake planting cost about $600 per year, while the money brought into the Kamloops District as a result of the Paul Lake attraction amounted to about $10,000 per year. It is suggested that intensive management of this type should be instituted only after adequate surveys have been made of individual bodies of water.

THE FOOD AND GROWTH OF THE YOUNG OF THE COMMON BULLHEAD, *AMEIURUS NEBULOSUS NEBULOSUS* (LeSUEUR), IN CAYUGA LAKE, NEW YORK

Edward C. Raney and Dwight A. Webster
Cornell University
Ithaca, New York

An analysis is presented of the food of 170 specimens of the young of the common bullhead, *Ameiurus nebulosus nebulosus* (LeSueur), taken at intervals from June 21 to October 10, 1938, in quiet coves of Cayuga Lake, Ithaca, New York. A large variety of organisms were utilized for food. The main staples were Crustacea (approximately 60 percent) and Diptera (approximately 25 percent). Almost all of the Diptera were chironomid larvae, while 80 percent of the Crustacea were ostracods and cladocerans. Considerable variation in the length attained by the common bullheads was noted in the collections taken after the middle of July. By October 10 the largest specimen was more than twice the length of the smallest. While the mean total length does not exceed 3 inches at the end of the first growing season, some individuals may reach a total length of nearly 4 inches.

COMMENTS FROM OUR READERS

Reply to Mr. Wall

Editor, the PROGRESSIVE-FISH CULTURIST:

I have read with interest Mr. Roy Wall's editorial,"After the Hatchery--What?" in the March-April issue of the PROGRESSIVE FISH-CULTURIST. Although I do not feel qualified to argue the merits of propagation, I see no reason why any fish-culturist who values his own work should avoid the issue Mr. Wall presents.

Most fish-culturists, I believe, would agree with Mr. wall that artificial propagation is no cure-all for angling ills. We know full well that restocking is of little value unless the conditions in stream or lake are proper for fish to live and thrive. We will grant that when deforestation, erosion and "phoney" flood control make streams unsuitable for planting, there is little the fish-culturist can do to restore them.

However,having known of numerous instances where properly conditioned streams and lakes responded well to artificial stocking,I am certain that there is a place for fish-culture in the conservation program.

Mr. Wall is right in condemning the methods of fish planting that have been practiced up to the present. As a fish-culturist engaged in distribution work,I have planted fish more than once in places where I was reasonably certain they would never "make the grade." Who made out the applications for those places? Sportsmen and other amateur conservationists. Who approved them? Officials who had never laid eyes on the places to be stocked,or else state wardens with no training or ability to judge the existing biological conditions. Who had authority to refuse to plant the fish? Not the fellow who carried out the distribution. In the present scheme of things he is just the grocery boy making the delivery.

As for paper fish, I have never planted any, but I can see that they would have a tough time surviving to catchable size, even in an improved stream.

Bring on your scientists, your stream biologists and survey men--the more the merrier! The State of Idaho is doing that very thing right now, and we are beginning to find out some of the things we need to know. For instance,there are investigations now in progress which may determine whether the habits of migration of our native cutthroat trout are such as to make it worth while to stock small feeder streams as a means of building up the population of the large streams they supply.

Bring on your experts! Tell us where we can best plant our fish so that they will survive to be caught. Take the applications out of the hands of amateurs and turn the job over to men who are supposed to know where the fish should be planted. Stop the pollution and the log-driving in places where they are endangering fish populations. Get us sufficient man-power so that we can improve the streams and lakes as thoroughly as the CCC is now improving the forests. Get together with state conservation forces and work out necessary, sensible and enforcable regulations for control of the fish take.

All this needs to be done ahead of any program of restocking from the hatcheries. When it is done, watch the fish-culturists go to town.

Donald C. Pryor
Fish-culturist in charge Mullan,Idaho,Station
Bureau of Fisheries

Watercress: Pro and Con

Editor, The PROGRESSIVE FISH-CULTURIST:

I am enclosing copy of circular letter being sent stations in the Western Region. The office might be interested in this information for publication in the PROGRESSIVE FISH-CULTURIST.

"The question has sometimes arisen as to what value, if any, watercress may have in the feeding of fish. So far as I know, this has not been conclusively answered up to this writing.

In the magazine "Hygiea" for March, 1939, there appears an article on the composition and vitamins found in watercress. These are given as follows:

Each 100 grams of fresh watercress is reported to contain:

Calcium	80.0	milligrams
Phosphorus	53.0	"
Iron	3.0	"
Copper	0.4	"
Manganese	0.5	"
Vitamin A	1400	International Units
Vitamin B	60	" "
Vitamin C	1000	" "
Vitamin G	60	Sherman-Bourquin Units

Since calcium and phosphorus are known to play an important part in the body structure of fishes, and vitamins A, B, C and G are presumed to be of importance, we may presume that the addition of fresh watercress to the food of fishes might result beneficially, particularly so if the food fed or available is deficient in such properties as watercress contains."

Fred J. Foster
Regional Director of Fish Culture
Bureau of Fisheries.
Seattle, Washington

Editor, The PROGRESSIVE FISH-CULTURIST:

With reference to Mr. Foster's letter, we have not tried watercress in the diet of trout but in view of our experience with other plants I am somewhat skeptical as to its value, especially with fingerlings.

Theoretically the addition of a small amount of green plants to the trout diet should be beneficial but like many other ideas it does not work out well in practice. We have tried adding small quantities of algae and green alfalfa to the food but the results have always been disappointing. It is almost impossible with the ordinary grinder to grind green plants fine enough that the fish will eat them. The result is that they pick out the meat and leave the plant material. It might be possible with a chopper to get the leaves so fine and so thoroughly mixed with the meat that the fish could not do this.

Possibly the use of green plants might give better results with larger fish. However, just at present we are trying to feed ground carrots to yearling trout in the hope that it would improve the color but so far we have not succeeded in getting the fish to eat them although the carrots are ground fine and thoroughly mixed with the meat.

H. S. Davis
In Charge Aquicultural Investigations
Bureau of Fisheries
Leetown, West Virginia.

NOTES AND NEWS

Hatching Shad Eggs

SUCCESS IN THE hatching of shad eggs at the Harrison Lake Station of the Bureau of Fisheries, where the water has usually been considered too acid for full development of shad and herring eggs, has been reported to the PROGRESSIVE FISH-CULTURIST by Bernard L. Pelz, Jr. Apprentice Fish-Culturist at Harrison Lake.

Water filtered to exclude slimy deposits that had been observed in the holding tanks was no more suitable than unfiltered water, Mr. Pelz found,nor did neutralizing the water in the hatching jars result in better than a 5 percent hatch. However, when well water was used in two hatching jars, slow development of the eggs was observed. These jars were taken to an experimental battery set upon the apron of the dam at the lake, and were supplied with lake water drawn off from a point approximately 14 inches below the normal lake level. The pipe intake was established at this level to draw off warmed lake water and to avoid both the surface water with its debris and the cold bottom water. In these jars the hatching percentage was 12 and 25 percent, respectively.

In 6 other jars later treated in the same way, hatching percentages ranged from 55 to 77. In one jar no eggs hatched, presumably because of some accident.

Potential Egg Production of Walleyed Pike and Black Bass

Potentially, a single pair of walleyes could produce enough offspring in a single season to exceed in numbers the total adult walleye population now present in Norris Reservoir, according to calculations made by Dr. Eschmeyer. The eggs in a seven and one-half pound female taken in December weighed 200.2 grams. Based on an actual count of the eggs in a 19.2 gram sample, the total number of eggs this female would have produced in 1940 was about 87,000. If Norris contained only one such female per ten acres of water, the number of pike eggs spawned annually would exceed 300,000,000. If one egg in 20,000 developed into an adult walleye, the total adult population would be increased by several hundred percent.

In comparison with walleyes, bass lay relatively few eggs. For the average size adult female bass in Norris Reservoir the number is roughly estimated as between 4,000 and 8,000 eggs. If there were only four females per acre, the number of bass eggs laid in Norris per year would be between one-half billion and one billion.

The figures for both bass and walleyes are probably conservative and the actual number of eggs produced in a favorable season may be several times the number suggested above. Age determinations show that the smallmouth and Kentucky bass and the walleyed pike now being taken in Norris Reservoir are the offspring of the few adults which existed in the river before impoundment. Those born in the reservoir in its first year (1936) probably first spawned in 1938, and their offspring were too small in 1939 to enter the catch. Until recently these species

presumably were not stocked. The natural reproduction is potentially so great that in a body of water the size of Norris Reservoir tremendous numbers of small fish need to be planted if we are to influence appreciably the total population by artificial stocking.--TVA,FOREST LOG, Vol. 5, No. 1. Issued by the Department of Forestry Relations, Tennessee Valley Authority.

Fish Rearing in the Tennessee Valley

As one contribution toward the rehabilitation of fisheries resources in the Tennessee Valley, the Authority has constructed two fish hatcheries and several rearing ponds at various locations throughout the area. The facilities, all of which are being or will be operated by the U. S. Bureau of Fisheries, and their present status are listed below:

Norris Fish Hatchery, located below Norris Dam, was built in two sections. The first section contains three ponds totaling six acres and has been in opera - tion since the spring of 1937. The second section contains eight hatching and two minnow ponds totaling eight acres and was completed in January 1940. The complete project contains sixteen ponds (including trout pools) totaling 14 acres, an administration building with living quarters for the hatchery operator, water supply and drainage systems. This hatchery is complete for full operation. The CCC cooperated in its construction.

Elk River Fish Hatchery, located in Limestone County, Alabama, contains seventy-seven ponds totaling one hundred and eleven acres, twelve concrete daphnia ponds, a fish-holding house, an administration building, two residences, water supply and drainage systems. Most of the construction was completed in August 1939, but seepage control was found necessary on much of the project and is under way at present. Twelve acres of ponds are now available for operation. The CCC cooperated in the construction.

Doaks Creek Rearing Pond is located in Campbell County,Tennessee,near Norris Reservoir. An earthfill dam impounds twenty-six acres. This was completed in January 1937 and has been in operation since that time.

Lost Creek Rearing Pond is located in Union County, Tennessee, near Norris Reservoir. An old mill dam was reconditioned and enlarged by students from the American Friends Service Committee to make a 7-acre pond. This rearing pond has been completed and in operation since September 1937.

Yellow Creek Rearing Pond is located in Rhea County, Tennessee, near Chickamauga Reservoir. An earthfill dam impounds sixty-eight acres and was completed in March 1940. Students from American Friends Service Committee and WPA cooperated in the construction.

Pryor Springs Rearing Pond is located in Limestone County, Alabama, near Wheeler Reservoir. A creosote timber dam at a gap in an old railroad fill impounds one hundred acres and is approximately 75 percent completed. The CCC is cooperating in the construction.--TVA FOREST LOG, Vol. 5, No. 1. Issued by the Department of Forestry Relations, Tennessee Valley Authority.

REVIEWS

SPAWNING INDUCED PREMATURELY IN TROUT WITH THE AID OF PITUITARY GLANDS OF CARP
By Arthur D. Hasler, Roland K. Meyer, and Howard M. Field.
ENDOCRINOLOGY, Vol. 25, No. 6, December 1939, pp. 978-983

THE USE OF HORMONES FOR THE CONSERVATION OF MUSKELLUNGE, ESOX MASQUINONGY IMMACULATUS GARRARD
By Arthur D. Hasler, Roland K. Meyer, and Howard M. Field.
COPEIA 1940, No. 1, March 30, pp. 43-46

THE FIRST OF these two papers on the application of endocrinological methods to fish culture, by several members of the Zoology Department of the University of Wisconsin, deals with the problem of inducing rainbow trout to spawn prematurely under the influence of hormones contained in the pituitary gland of the carp, and is of interest chiefly because it opens the door to little explored fields of operation. The second paper describes a practical application of the methods previously reported and indicates that the findings are of much more than theoretical importance.

The paper in ENDOCRINOLOGY gives an account of 4 experiments testing the effects of weekly injections of fresh and acetone-dried pituitary glands of carp and of such mammalian preparations as pregnant mare serum and a follicle stimulating hormone fraction prepared from sheep pituitary. Three of the experiments were performed on sexually mature rainbow trout (Salmo gairdnerii) and one on German brown trout (S. fario) from the regular hatchery stock of the Madison Fish Hatchery. Injections of rainbow trout were begun in mid-December, approximately 6 to 7 weeks before the beginning of regular hatchery spawning operations.

In the first experiment, in which the rainbow trout were kept in indoor brood house troughs supplied with running spring water, 19 percent of the females spawned upon stripping one week after the initial injection of carp pituitary, and 45 percent by the second week. In a second experiment conducted in the outdoor raceways of the Madison Hatchery, 95 percent of the females released all of their eggs on stripping by the end of the third week, and some spawned spontaneously. In this experiment approximately a third received injections of fresh carp pituitary, a third acetone-dried carp pituitaries,and a third served as controls. Since no difference in the relative effectiveness of fresh and dried pituitary could be discovered, the use of dried material is recommended because of the convenience of storing the material in this form.

In a third experiment, mammalian preparations failed to induce spawning after four weeks during which each fish received one injection per week.

In the fourth experiment, injections of carp pituitary were used successfully to hasten the ovulation period of German brown trout during the regular spawning period, which normally extends over about 6 weeks.

The authors summarize their results in the statement that "The data submitted indicate definitely that the injections of suspensions of pituitary glands of carp

have a hastening effect on the maturation and ovulation of the trout ovary, and that eggs can be produced, fertilized and developed normally at least 6 to 7 weeks in advance of the onset of the normal spawning period."

These significant results were obtained through experiments which, as the authors point out, were merely preliminary to further work. In future experiments they plan to depart from the routine of weekly injections thus far adhered to, and by varying the size and frequency of injections attempt to determine the earliest time at which spawning may be induced.

Within a few months after performing the experiments reported above, Drs. Hasler, Meyer, and Field were given an opportunity to apply the method of hormone stimulation to a practical conservation problem. On the Chippewa River near Winter, Wisconsin, a power dam obstructs the spawning migration of muskellunge and other fish. As a result, the muskellunge mill around for several weeks below the dam in a futile attempt to reach their spawning grounds, and finally return to the lower river without having spawned. Although fish-culturists have tried holding the muskellunge in ponds, the females remained "hard."

It was decided to try injections of carp pituitary in an effort to overcome the "hard" condition of the captive muskellunge. The males were found to be ripe without treatment. As the females were transferred to the holding pond, however, each received an intraperitoneal injection of 50 mg. of acetone-dried carp pituitary. After injection the fish were tested daily by experienced spawn takers. Nine of 11 injected females spawned 3 to 4 days after a single injection of carp pituitary, while the remaining two were given 2 injections each and spawned 6 days after the first injection. Each of the injected females yielded eggs, of which the normal percentage hatched subsequently. The fry were planted in flowage waters. None of the controls spawned during the period of the experiment.

This forced spawning of captive muskellunge simulates the results of van Ihering in South American, when certain fishes were induced to spawn prior to the rainy season (which supplies the normal impetus to spawning) by injections of fish pituitary. It is obvious that the possible applications of hormone stimulation to problems of fish culture and fish conservation are many, and that the next several years should see interesting developments in this field.

R. L. Carson

A MANUAL OF AQUATIC PLANTS

By Norman C. Fassett
New York: McGraw-Hill Book Company, Inc. 382 pp. 1940 ($4.00)

NEW BOOKS ARE greeted frequently with enthusiasm, but very rarely is that reception properly described by the word "joy." For many years almost every biological investigator concerned with aquatic and semi-aquatic animals and their habitats has lamented the non-existence of an adequate and practical manual of aquatic plants. Several good works on phytoplankton organisms have long been available but, in general, literature that would facilitate identification and study of floating, submerged and emergent aquatics has been fragmentary, scattered and frequently too technical for the wise use of anyone except a professional botanist.

The author describes his book in the introduction: "The simplest way to identify a plant is to examine a set of pictures until one is found that resembles it. This becomes not practical when a large number of species is involved. Moreover, many kinds of plants are superficially alike, and even if the pictures show the differences the user must be directed as to what points to observe. It is on this principle that these keys are based. The text is essentially a set of directions for looking at the pictures."

Part I is a key, accompanied by illustrations and founded insofar as possible upon characters that permit the identification of sterile specimens. With the aid of this key the plant may be determined as to genus or family. Part II contains illustrations in greater detail,including both vegetative portions and the fruits, accompanied by sufficient descriptive information in the form of simple keys to make possible identification to genus and frequently to species. Appendices contain lists of plants utilized by wildlife and by fishes, each accompanied by references. The general make-up is simple, direct, and accurate.

The usefulness of the book to investigators and those engaged in management projects will be great. It should become one of the few indispensable references in the possession of every field biologist.

It must be emphasized that the scope of the manual includes only macroscopic aquatic plants that may be found in the region from Minnesota to Missouri and eastward to the Atlantic (exclusive of bog, tidal and saline habitats). May the success of Dr. Fasset's manual serve as an inspiration for a similar work that will embrace the plants from green algae to goldenrod in the western part of the continent!

H. J. Deason

(Continued from inside front cover)

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